Bell Laboratories RECORD

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THE COVER: The Laboratories has recently announced a new break-through in solid-state technology. This device, which might be termed a solid-state spin oscillator, is shown with its inventors: Harold Seidel, George Feher and Derrick Scovil. **(See page 109.)**

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Bell Laboratories Digital Computers

E. G. ANDREWS *Military Systems Engineering*

During the past fifteen years a revolution has taken place in communications, atomics, ballistics, electronics and aerodynamics. The rapid advance in these arts has been accompanied by an avalanche of problems which required the evaluation of enormously complicated equations and a staggering amount of computation. Bell Telephone Laboratories mathematicians were early to take up the challenge of finding a way to relieve man of this exacting and time-consuming burden. Telephone switching techniques were the basis for the early electromechanical computing machines which have culminated in electronic automatic digital computing systems able to outperform the human mind in many respects. The modern digital computer is now a truly indispensable tool on the frontiers of science and technology.

Supposing a group of noted mathematicians decided it would be more convenient to have 400 degrees in a circle than the present 360 degrees. By using a modern digital computer, new sine and cosine tables could be prepared in a single day. Without such a computer, this would be an extremely tedious process. Although this is a highly improbable example, it does give some indication of the type of problem that could be solved readily by a digital computer.

The original computers designed at Bell Telephone Laboratories were intended for similar purposes: to increase the speed and accuracy of making the complex calculations required in circuit design, and to eliminate the tedium and errors in making these computations using desk calculators. Digital computer technology has now advanced to the point where it is possible to perform computations that were formerly considered impractical because of the volume of hand calculating involved. Such things as simultaneous differential and partial differential equations are now almost routine problems, done usually in a small fraction of the time previously required.

From this start, as a device for performing more or less direct numerical calculations, the use of the digital computer has spread to many other fields. It is now used as a control device for the analysis of system performance, for statistical and scientific data reduction, and in industrial and administrative automation. In the Laboratories and the Bell System, applications for the modern computer include their use for the so-called "throwdown machine"* for indicating the optimum amount and

* RECORD, *January*, 1953, *page* 2.

Fig. 1 — Remote operating station and storage input tables for the Network Problem Computer (Model VI). Originally installed at the Murray Hill Laboratory in 1949.

arrangement of switching equipment in machine central offices; and the AMA computer used to determine customer charges on direct dial local and suburban traffic.

Basically the digital computer is a machine which solves problems using arithmetic operations — addition, subtraction, multiplication and division. The analogue computer, on the other hand, solves problems by mathematical analogy.

In its broadest sense, the digital computer differs from the ordinary desk calculator only in that its arithmetic operations are performed according to a prescribed sequence automatically. As experience was gained from simply "doing arithmetic automatically," wider applications for the computer become apparent. Many modern computers are actually data processing machines, where little arithmetic as such is done. The machine receives a mass of data, reduces it, analyzes it and presents it in a more usable form. The AMA computer is such a device. It accepts raw data of three separate types and converts this into one item of billing information. In doing this, a few arithmetic opera-

TABLE I — STATISTICAL INFORMATION ABOUT BELL LABORATORIES COMPUTERS, MODELS I TO VI

	Model I	*Model II*	*Model III*	*Model III**	*Model IV*	*Model V*	*Model VI*
LOGICAL DESIGN FEATURES							
Number of built-in routines	2	0	0	0	0	4	200
Decimal point	Fixed	Fixed	Fixed	Fixed	Fixed	Floating	Floating
Discriminating action	None	Note 1	Note 1	Note 1	Note 1	Exten.	Yes
Multiplication	Yes	Note 2	Yes	Yes	Yes	Yes	Yes
Division	Yes	No	Yes	Yes	Yes	Yes	Yes
Square Root	No	No	No	No	No	Yes	Yes
Indeterminate arithmetic	No	No	No	No	No	Yes	Yes
Special trigonometric features	No	No	Note 1	Note 1	Note 1	Yes	No
Special logarithmic features	No	No	No	No	No	Yes	No
Round off — automatic or program	No	Pro.	Pro.	Pro.	Pro.	Auto.	Auto.
Subscript knowledge	No	No	Yes	Yes	Yes	No	No
Number of addresses in code		1	1 or 2	1 or 2	1 or 2	3	3
Self checking	No	90%	100%	99%	100%	100%	100%
PHYSICAL DESIGN FEATURES							
Number of relays	450	440	1,400		1,425	9,000	4,600
Pieces of teletype equipment	4	5	7		7	55	16
Number of number registers	4	7	10	14	10	15	12
Number of digits per number	8	2 to 5	1 to 6	1 to 6	1 to 6	1 to 7	3, 6, 10
Multiplication time in sec. per 5 digit number			1	1	1	0.8	0.8
Number of problem stations	3	1	1	1	1	3 and 4	2
Arranged for unattended operation	No	No	Yes	Yes	Yes	Yes	Yes
Number notation with self-checking bi-quinary	No	Yes	Yes	Yes	Yes	Yes	Yes
"2 out of 5"	No	No	Yes	Yes	Yes	No	No
"3 out of 5"	No	Yes	Yes	Yes	Yes	Yes	Yes

* This column applies to the Model III after its modification in 1949.
Note 1. Very limited application.
Note 2. With multiplier specified in program.

tions are performed, redundancy is eliminated and data not required are discarded.*

Bell Telephone Laboratories and its predecessor have been engaged in the design and development of automatic data processing systems – a fair description of a telephone switching system – for more than fifty years. It was not until 1937, however, that George R. Stibitz, a Laboratories research mathematician, noted that many of the design techniques employed in dial system switching were applicable to the design of an automatic computer. The "Complex Number Computer" took about three years to design, engineer, and test and was introduced in January, 1940, at the Fall Meeting of the American Mathematical Society. Problems introduced by telephone at Hanover, N. H., the scene of the conference, were computed in New York and the answers sent back to the teletype answer printer in about a minute.

Since this event, Bell Telephone Laboratories has designed and built six more digital computers. The important design features of these computers are summarized in Table I. The "Complex Number Computer" was redesignated as Model I and was replaced by Model VI in 1949. These two models are the only computers which were built for the Laboratories own use.

Models II through V were designed and built for national defense agencies of the Government at various times between 1943 and 1947. The basic construction principles of relay computing frames and teletype answer printers remained pretty much the same in all models. Improvements, such as paper tape inputs and outputs, complete self-checking of all operations, stopping on failure, bi-quinary number notation, unattended operation, subscript notation and permanent wiring of functions, along with a general increase in size and versatility, were incorporated in succeeding models as the computing art developed. As these physical improvements in computer technology evolved, three basic design considerations also became very apparent.

The most important of these design features was simplicity in the introduction of data, or programing ease. Even with this factor uppermost in the designer's mind, most problems require considerable preliminary mathematical work before they can be introduced to the computer. A second important design consideration is provision for adequate and accurate storage of intermediate results. The third factor which proved to be basic to "automatic arithmetic" was control of the sequence of the mathematical operations within the computer necessary to obtain a solution.

The vital part of the computer is the electromechanical (relay) type equipment. In the case of the Model V, relay racks occupy the space of several large rooms. Size of such an order and the

* RECORD, *July*, 1953, *page* 53.

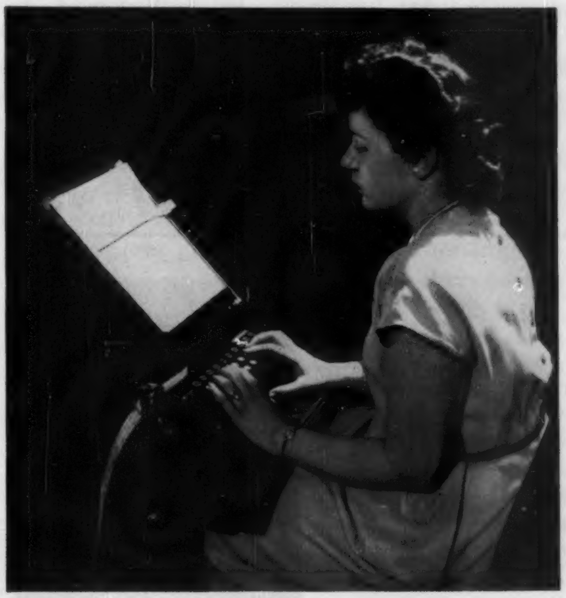


Fig. 2 — Vivian J. Alling preparing punched tape for a problem on the Model II Computer.

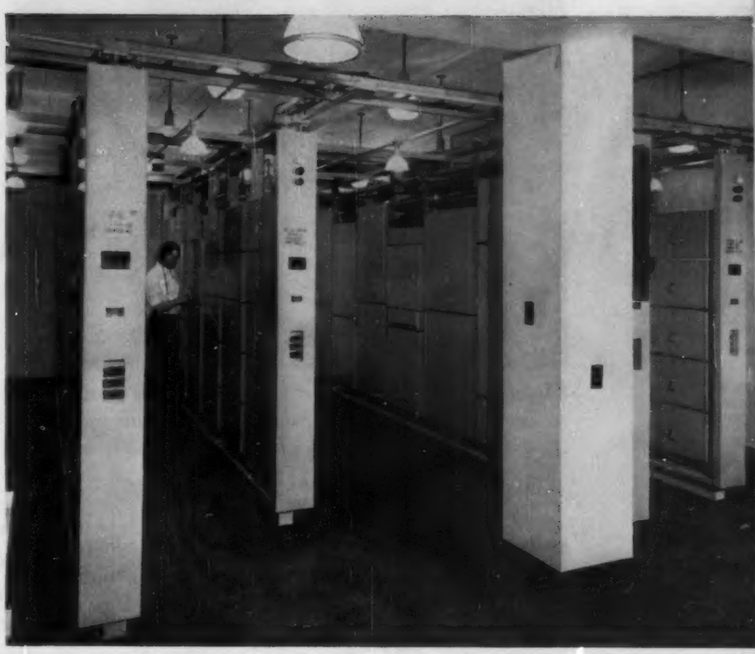


Fig. 3 — Relay equipment room of the Model V Computer installed at Ballistics Research Laboratories, Aberdeen, Md.

Fig. 4 — Punched instruction tape being loaded into an input station of the Model VI Computer by Ann Madden.

finite operating time of electrochemical relays have disadvantages in certain computer applications. Target selection and automatic control of fairly simple machinery are examples of such applications. For these two reasons – size and computing speed – most of the current design and research effort on computers in the Laboratories is being spent on electronic digital computing. Electronic computers are available and many are currently in use. Reliability, however, using standard vacuum tubes is still a problem in the electronic computer. Further advances in electron devices such as the barrier grid tube,* magnetic core memory devices, the ferrite bead and extremely reliable electron tubes are having a profound influence on the development of digital computers.

The transistor is an obvious choice for overcoming the problem of computer size. The TRADIC (TRansistor-DIgital-Computer)† developed recently by the Laboratories for the Air Force, contains about 800 transistors and 11,000 germanium diodes in about 3 cubic feet. The 250 steps in a typical computation on the TRADIC can be performed in 0.015 of a second. Other transistor computers are being developed in the Laboratories and improvements are constantly being made in this area. A conservative prediction concerning the use of transistors would be that no digital computer application of acceptable reliability need be shelved because of lack of space. In fact, a computing system with the extreme versatility afforded by thousands of transistors is already an actuality.

The digital computer has a tremendously wide scope. As a research tool, as a system control element and as a data processor it has recently come into its own. Its resources for industrial and administrative automation are currently being harnessed. Recently a digital computer was programed to design another computer, and did it. Serious consideration is also being given to using a digital computer for the development of some parts of the electronic central office. The modern computer is fast becoming the perfect wedding of the sciences of mathematics and logic. The only plateau on the present horizon of computer progress is an economic one. Eventually a point will probably be reached, where the curve will go upward again as computer technology is further explored.

* Record, *June*, 1956, *page* 261. † Record, *April*, 1955, *page* 155.

THE AUTHOR

E. G. Andrews joined the Western Electric Company as an inspector of panel machine switching systems at Kansas City in 1922. He served in the same capacity in Atlanta and New York City until he transferred to the W.E. Engineering Department in 1924. When the Laboratories were formed from that department in 1925, Mr. Andrews joined a group responsible for writing engineering and maintenance specifications for central office equipment. During World War II, he was engaged in the development of radar training devices and relay digital computers. Since the war, he has been concerned with various phases of planning and programing for computers used in military systems.

Performance of the A2A Video Transmission System

R. W. EDMONDS *Transmission Engineering*

In addition to long-distance transmission systems required for nationwide monochrome and color television, as many as twelve short-distance or local links may be involved in a typical coast-to-coast TV network. To maintain high-fidelity TV at all points, the distortions inevitably introduced by each link must be kept to extremely small values. The new A2A local video system has been designed to meet these requirments and has given excellent service in both a field trial and in several operating installations.

As part of an over-all improvement program in the Bell System's television services, the new A2A local video transmission system* has been designed for short-distance links. Local systems are needed, for example, to provide links from a TV studio to a broadcaster's control center, from a control center to a transmitter, from one studio to another, or from a control center to a Bell System operating center where connection might be made to long-distance transmission routes.

The new system is a broadband wire-transmission system designed to meet requirements necessary for the transmission of monochrome and color television. It provides video transmission for frequencies up to 4.5 mc over balanced pairs of conductors designed for such use. As many as twelve A2A links in tandem may be involved in a coast-to-coast, 4,000-mile hookup, and the various distortions that are inevitably introduced must be kept to a low over-all level. This means that the tolerance limits of each local section must be especially rigid. The left part of Figure 1 shows how a local television setup might require several A2A systems in tandem at a city where the picture is originated, and the right part of Figure 1 illustrates how additional A2A systems would be required for a transcontinental television transmission network.

A large number of variables must be considered in designing a video transmission system, but this discussion will deal mainly with three of the more important. These are the transmission-frequency characteristic, the signal-to-noise performance and the modulation characteristics.

The transmission-frequency characteristic required for television presents a distinct challenge; it must encompass a band of frequencies extending from near zero to more than four megacycles, a range of over seventeen octaves. All frequency components within this band must be transmitted faithfully with respect to amplitude and relative time-delay. To insure that an extremely good frequency response exists over the useful video range, uniform transmission is provided up to 4.5 mc, rather than to the 4.2 mc nominally required. Such a transmission characteristic reduces the possibility of a type of picture impairment that results from an extremely sharp cutoff at the upper edge of the useful band. Many types of degradation in picture transmission may result if the transmission-frequency characteristic fails to meet the above conditions closely enough.

Second, the signal-to-noise performance of the

* RECORD, *April*, 1956, *page* 126.

system should meet over-all network requirements. On the television screen, noise can result in moving spots, bars, "salt-and-pepper" effect, or erratic synchronization. Interference may be of the cross-talk type, where an unwanted signal is introduced from another transmission system, or may result from a variety of other sorts of "noise" – for example, that from power mains or automobile ignitions.

The third consideration, modulation characteristics, is perhaps a little more difficult to appreciate, but is very important to the successful transmission of color television signals. Modulation effects, called "differential gain" and "differential phase," are types of distortion that may degrade color TV picture quality, but to describe them we must first consider the makeup of a color signal.

A color television signal consists basically of three major components: the parts of the signal that determine hue, saturation and luminance. Hue describes the actual color – whether it is red, green, blue, and so forth – and saturation describes its strength or "vividness" in such terms as pale, deep, pastel, and the like. The luminance component is similar to the monochrome signal used for black-and-white television and determines general brightness. Hue and saturation are transmitted by varying both the amplitude and phase of a 3.58-mc color-carrier frequency. Amplitude modulation of the color carrier is the principal factor that determines saturation, while hue is determined chiefly by phase modulation. The phase- and amplitude-modulated color carrier is added to the luminance component to form the complete color signal.

Differential gain and differential phase may now be defined in terms of these components of the signal. Differential gain is that type of distortion introduced if the gain of the transmission circuit at the carrier frequency of the color signal (saturation) varies with the amplitude of the luminance signal. Differential phase is the distortion introduced if the phase of the system at the color carrier (hue) varies with the amplitude of the luminance signal. The control of these two types of distortion within close limits is very important in circuits transmitting color signals. Otherwise the hues and intensities will not be satisfactorily reproduced on the receiving picture tubes.

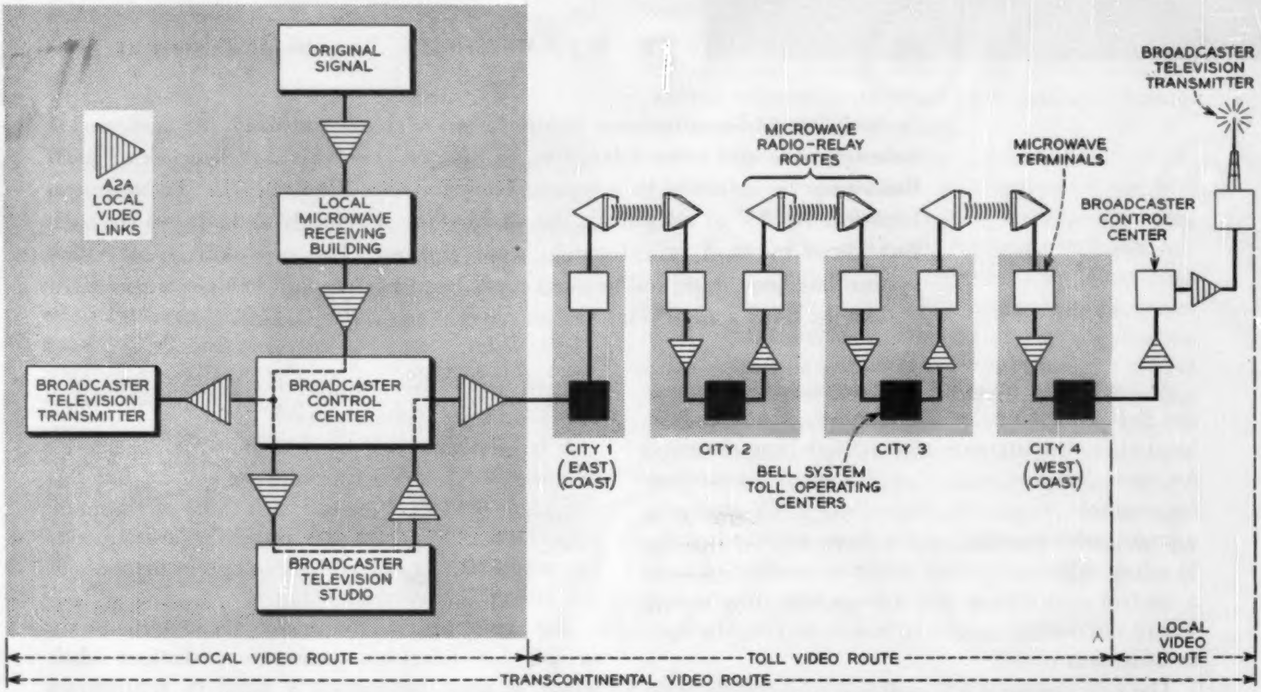


Fig. 1 — Left, typical intra-city television network, showing how several A2A links might be used; right, typical coast-to-coast television hookup, showing role of numerous A2A links in over-all connection.

The above are, in general, the more important transmission requirements for any monochrome and color video transmission system, and we may now look at the A2A system to see how these standards have been met. A field trial of A2A equipment was conducted in New York City to insure that the requirements established for this

new system were realized in practice. The circuit, Figure 2, extended from 30 Rockefeller Plaza to 32 Avenue of the Americas.

The measured gain-frequency performance of the field-trial circuit is shown in Figure 4. Residual gain ripples are less than plus or minus 0.04 db up to about 4.5 mc. Above this frequency, response of the circuit gradually rolls off, the 6-db loss point occurring at about 7 mc. The gain-frequency performance of the new system is well within the design objectives for satisfactory use as part of a transcontinental network.

In an A2A circuit, the gain-frequency characteristic may be adjusted with fixed cable equalizers and a number of manually adjustable variable equalizers provided in the receiver.* The variable equalizers have a total of nine different "shapes" (gain or loss characteristics) that enable the transmission path to be equalized regardless of how the flexible office cable and the interoffice cable vary from the average. It was found in the field trial that after the initial lineup of the system, the only variable equalizer setting that needed to be changed appreciably was the cable-length equalizer. This equalizer produced the inverse of cable-shape loss, caused by a variation in the loss of the underground video cable due to temperature variation.

The A2A system was also designed to have a low value of random noise – a type of interference that produces an effect on a picture tube called "snow." Random noise is of the general type obtained by electron tube amplification of thermal noise, but is not necessarily confined to that source. It covers a wide band of frequencies, but is predominant at the top of the frequency band of the A2A system. The maximum allowable distance between A2A repeaters is primarily restricted by this type of noise.

The performance of a video circuit for random noise is expressed in terms of a signal-to-noise ratio – the ratio of what is termed the "peak-to-peak" value of the signal to the "root-mean-square" weighted noise. Noise power is weighted to give more prominence to the lower-frequency components, because noise at the higher-frequency end of the band has less effect on picture quality. Measurements on the field-trial circuit were made with a noise meter designed for exploratory work, and these measurements indicated the signal-to-weighted-random-noise ratio to be approximately 71 db. This noise performance was in good agreement with the calculated signal-to-noise ratio for the specific cable lengths of the field-trial circuit.

Impulse noise is another type of interference that was taken into consideration in the A2A design. It is usually composed of intermittent bursts of voltage. On home television viewing sets it is commonly caused by the ignition systems of passing automobiles. In transmission of the signal through the telephone system it may come from several sources, the most common being operation of alarms

* Record, *September*, 1956, *page* 346.

Fig. 3 — R. W. Clausen, New York Telephone Company, inspecting amplifier circuit of A2A equipment used in New York City field trial.

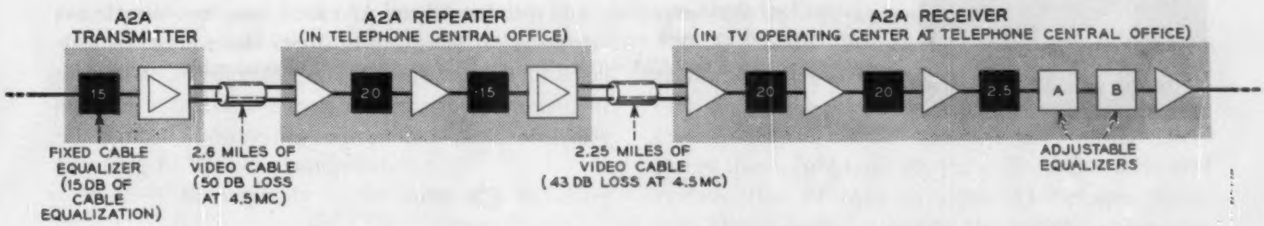


Fig. 2 — Circuit for A2A video transmission system performance tests used in New York City field trial.

and relays in telephone central offices. Picture impairments resulting from impulse noise are sometimes called "pigeons," since the spots seem to fly across the picture.

The performance of a video circuit for impulse noise is expressed in terms of another type of signal-to-noise ratio; in this case, the ratio in decibels of the "peak-to-peak" signal to the "peak-to-peak" impulse noise. The objective, at the receiving end of a video circuit, is to have a signal-to-noise ratio several decibels better than a value determined subjectively for the threshold impulse noise limit.

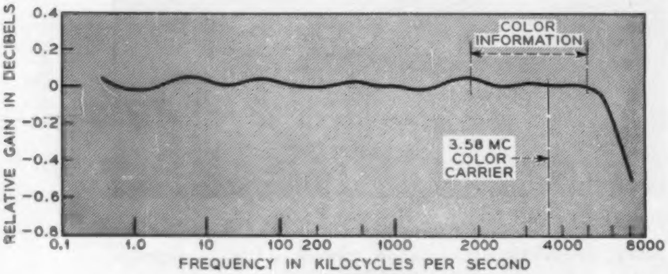


Fig. 4 — Actual measured performance of the A2A video transmission system field-trial circuit.

Measurements on the field-trial circuit indicated this signal-to-noise ratio to be 20 db, which is appreciably better than the minimum noise-performance level for this type of circuit.

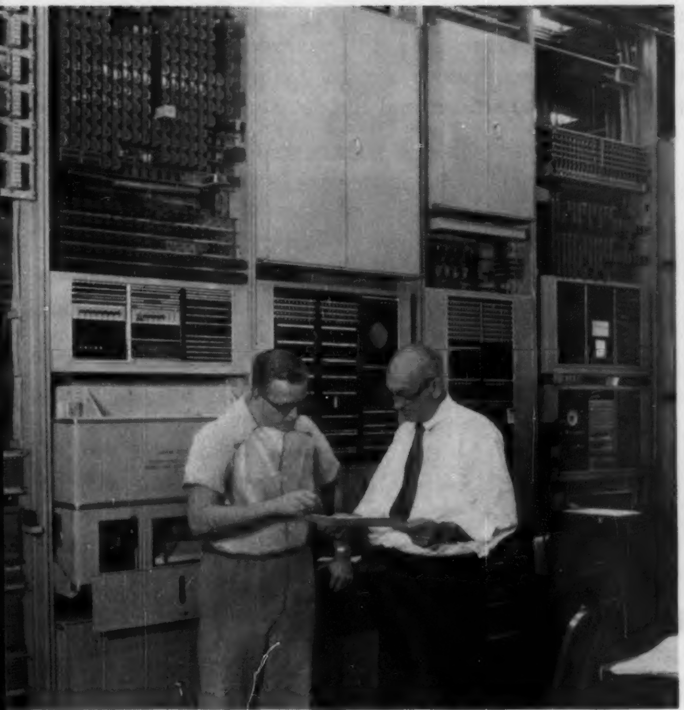
An important feature of the A2A system is the low response to microphonics, a third type of noise and one which results from mechanical disturbances that cause the elements of an electron tube to vibrate. The resultant variation in tube characteristics will cause any signal being handled to be modulated at the vibration rate. In the case of video transmission, the effect on pictures is to add a series of horizontal bars to the picture. These usually move and change in size in accordance with the amplitude and frequency of vibration. During the field trial, it was found that mechanical jar and acoustical noise had much less effect on the newer A2A system than on the older A2 system.

Finally, the differential gain and phase properties were also measured in the field trial of the A2A equipment. The performance of a video circuit with respect to differential gain is expressed as the ratio, in db, of the change in circuit gain at 3.6 mc when the luminance signal is varied from black to white. Measurements of the field-trial circuit showed the differential gain to be 0.3 db, which is within the design requirement. The second of these two properties, differential phase, is expressed as a change of phase, in degrees, of the color carrier as the luminance signal is varied from black to white. Measurements of the performance showed that differential phase was also within the design requirement, less than plus or minus 0.25 degrees.

The performance of the new video transmission system, as indicated by the results of the field trial, shows that the system meets the design objectives for satisfactory use as part of a transcontinental network for the transmission of monochrome and color television signals.

THE AUTHOR

R. W. Edmonds joined Bell Telephone Laboratories in 1935, and received his B.S. degree in E.E. from the Newark College of Engineering. Until 1942 he worked on local transmission engineering problems, including transmission engineering work on the New York City weather-announcing system. During World War II he was concerned with special coding systems for military applications. In 1947, Mr. Edmonds became a member of a group formed to handle television systems transmission engineering, and since that time has been concerned with transmission engineering problems in connection with the use of the L1 carrier system for television signals, and with the A2 and A2A local video systems. He has also engaged in work on the characteristics of video cable. He is presently continuing work on the A2A system and on field problems of television test equipment.



Conversion of Automatic Ticketing to AMA

A. S. MARTINS *Switching Systems Development*

The automatic message accounting system, developed by the Laboratories after World War II for use with crossbar switching systems, is being adapted for still wider applications. As direct distance dialing becomes more and more prevalent, older billing systems which require hand processing, such as Automatic Ticketing, are being converted to AMA. Such conversions, carried out in working central offices, present a number of intricate problems to be solved by joint efforts of the American Telephone and Telegraph Company, the Operating Company concerned, the Western Electric Company and Bell Telephone Laboratories.

Automatic ticketing* for step-by-step offices was introduced in 1944 with an installation in Culver City, a suburb of Los Angeles. It was the first step toward automatic processing of billing information. Instead of hand-written charge tickets for extra-charge calls, tickets were automatically printed from information derived from the calling and called telephone numbers and from timing circuits. Further development of automatic processing apparatus was deferred until after World War II. Much of the post-war development effort was devoted to local and toll crossbar systems, and the development of mechanical processing equipment for automatic ticketing (AT) was abandoned.

In 1948, the capacity of the automatic ticketing system was expanded from 200 toll-ticketing trunks, 20 senders, and 3 identifiers to 1,000 trunks, 100 senders and 10 identifiers. Many new installations were put into service in and around Los Angeles and San Francisco, and the number of ticketed calls increased tremendously. For example, 29 million billable tickets were processed in 1950, 78 million in 1952, and it is estimated that by 1958 this figure will reach 280 million per year.

Figure 1 is a block diagram of the major circuits of the automatic ticketing system. A message ticketer and mechanical timer are permanently associated with each trunk circuit. The identifier determines the calling number, the called-office code and certain other information required for proper charging. This is passed along to the sender, which controls the printing of the details of the call. At the

* RECORD, *July* 1944, *page* 445; *October* 1944, *page* 550; and *December* 1944, *page* 633.

proper time, the sender calls in a day-and-hour circuit to secure the originating time of the call. After all details of the call except the conversation time have been printed on the ticket, the sender releases. The timer in the trunk circuit starts when the called customer answers. When disconnect occurs, the conversation time is automatically printed. The completed ticket, which is shown in Figure 2, requires manual processing.

Subsequent development of automatic message accounting (AMA)* for the No. 1 and No. 5 crossbar systems led to a study of the possibility of converting automatic ticketing installations to AMA operation. This study showed that substantial savings would result from modifying the equipment in order to perforate the charge information on AMA paper tape, as shown in Figure 2.

Since the automatic ticketing equipment would be undergoing major revisions during the conversion to AMA operation, it was decided to include in the new design facilities for direct distance dialing and multifrequency outpulsing.

Reduced maintenance effort, faster and more accurate testing, and better coverage of trouble conditions are also realized by replacing the manual trunk-test circuit and lamp-type trouble indicator with an automatic trunk-test circuit and a mechanical trouble recorder.†

Modification of the automatic ticketing system is shown in the block diagram of Figure 3. The ticketer and timing switches are removed from the trunk, the ticket-printing control features are removed from the sender, and the day-and-hour timing circuit is eliminated. Standard AMA circuits, such as the call identity indexer, recorder, recorder connector and master timer, are added with only minor modifications to accommodate them for use in step-by-step offices. The master timer takes over the functions formerly performed by the day-and-hour circuit. New transverters using wire-spring relays are provided, and a new connector gives the senders access to the transverters.

As in automatic ticketing, the identifier determines certain charge information and passes it along to the sender; however, instead of controlling the printing of a ticket, the sender now waits until it has sufficient information to make an initial entry and calls in a transverter. The sender then transmits all details of the call to the transverter, which attaches a recorder to perforate the initial entry on AMA tape. When the transverter has completed its functions, it sends a release signal to the sender and

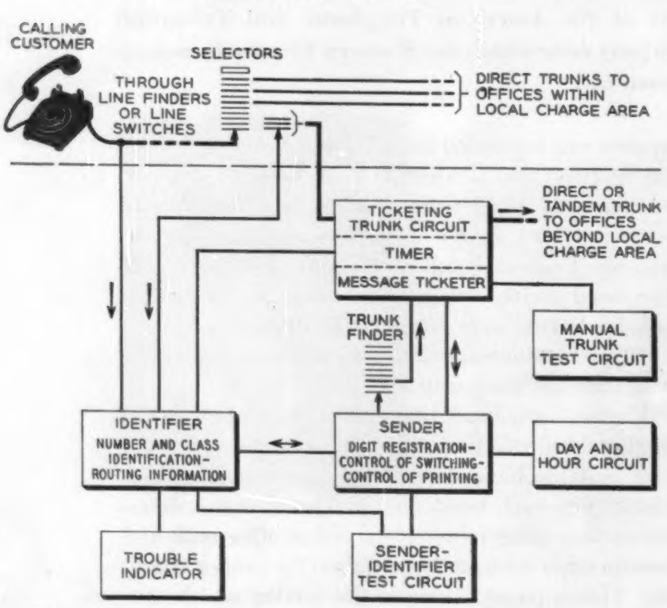


Fig. 1 — Block diagram of the automatic ticketing system.

Fig. 2 — Comparison of two printed tickets with a perforated AMA tape carrying the information listed on the ticket for many more calls.

* RECORD, *September*, 1951, *page* 401. † RECORD, *May*, 1950, *page* 244.

also releases itself. The trunk circuit, the call identity indexer, and the recorder control the perforation of answer and disconnect entries on the same strip of AMA paper tape.

As might be expected, the time required to perforate an initial entry on the AMA tape is considerably less than that required to print the corresponding information in sequence on a ticket. In automatic ticketing, printing takes place while the sender is outpulsing. Field experience has proved, however, that in almost all cases printing continues for several seconds after outpulsing is completed. In the modified system, the initial entry is usually completed before outpulsing, resulting in reduced holding time for the sender.

The circuit arrangement of the new transverter, shown in Figure 4, is similar to that of other AMA systems. Because the first digit dialed into the sender may be the 3rd, 4th, or 5th digit dialed by the customer, depending on the number of step-by-step selectors used before the trunk is reached, the kind of information on a particular set of leads between the sender and the transverter varies from call to call. This new transverter therefore recognizes control signals from the sender and rearranges the information as required. Since the sender transmits the calling-line information to the transverter in directory-number form, transverter access to a translator, as done in other systems, is unnecessary.

To arrange for direct distance dialing, relays are added in the identifier to furnish routing information for the X0X and X1X area codes.* The sender, Figure 5, is modified to register the extra digits, pass the additional information to the transverter, and control the outpulsing sequence. For compatibility with local and toll crossbar offices to which the equipment must connect, a multifrequency (MF) outpulsing class in the sender is used when called for by the routing information from the identifier. The sender, when required, can outpulse code digits on a loop basis (dc pulses) to control step-by-step routing selectors, and then shift to MF pulsing for the remainder of the digits.

To prevent an overload condition in a distant office from "backing up" and creating a false overload condition in the local office, an inter-sender timing interval is provided that is considerably shorter than the regular sender time-out interval. If a "sender attached" signal is not received from the distant office within the allotted time, the local sender is released and the calling customer is given a reorder signal. If the distant sender is attached soon enough, the inter-sending timing interval is cancelled and the regular sender time-out interval takes over.

* Record, *May*, 1951, *page* 197.

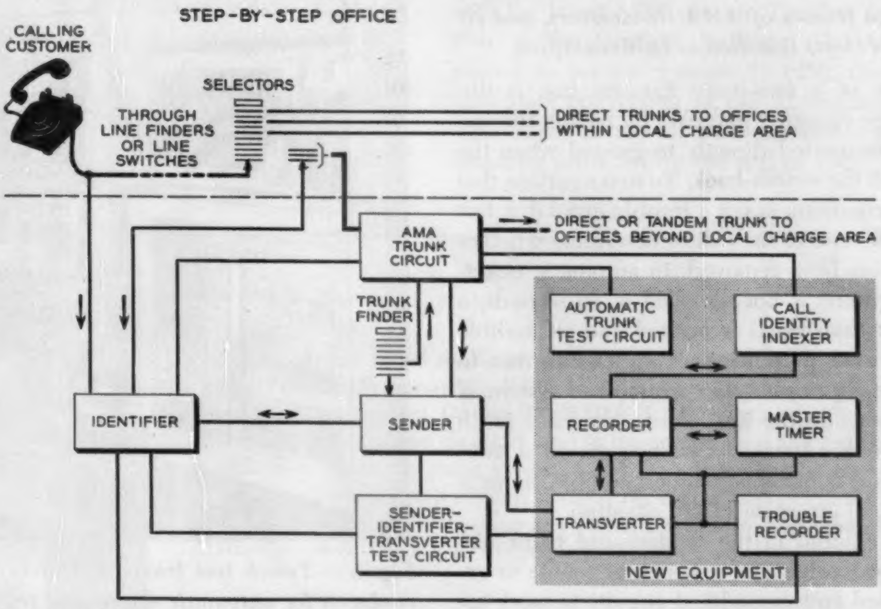


Fig. 3 — Block diagram showing the arrangement of a step-by-step office of Figure 1 for AMA operation after conversion.

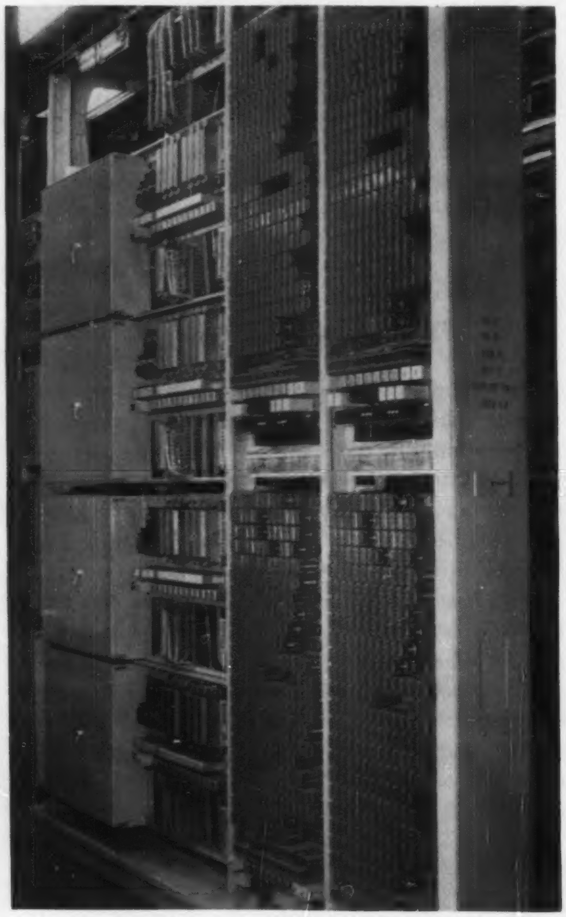


Fig. 4 — Two frames of AMA transverters, and recorder frame (left) installed in La Brea Office.

One party of a two-party flat-rate line is distinguished for charging purposes by having the station ringer connected directly to ground when the receiver is off the switch-hook. To make certain that the ground condition is not a trouble ground, a test is made at the end of the call to determine whether the ground has been removed. In automatic ticketing, if the ground is not removed in 10 seconds, a longer ticket than usual is printed and an audible alarm is sounded, permitting a maintenance man to check the line in trouble. In the modified system, if ground remains on the line, the sender calls in an identifier after the 10-second waiting period, a trouble record card is punched, and an audible alarm is sounded to call attention to the situation.

Changes required in the senders and trunk circuits are so extensive that it is impracticable to arrange modified and unmodified circuits to work together during the transition period. The new trunks and senders, therefore, are arranged to operate as a separate subgroup within a sender group. Fortunately, changes required in the identifiers are not quite so extensive. Since all identifiers must work with both old and new senders and trunks, the sender transmits a signal to the identifier to tell it which billing system requires information. Suitable switching then takes place in the identifier to accomplish the changeover. When the conversion is completed, the temporary switching equipment used for this purpose is removed.

The sender-identifier test circuit is expanded to include tests of all transverter features and the additional digits required for direct distance dialing. A relay matching circuit is used to check the AMA output information. Any mismatch of information

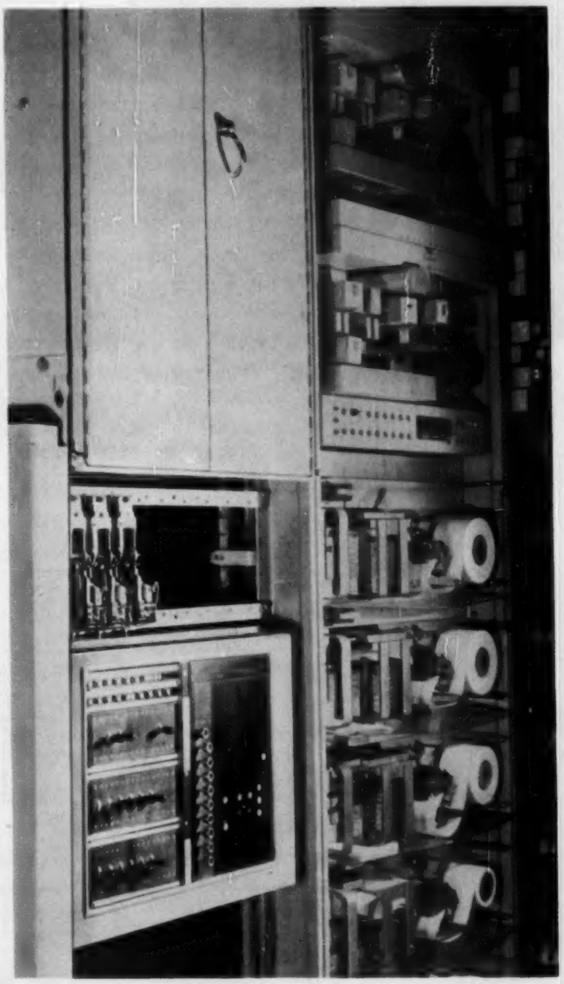


Fig. 5 — Trunk test frame at Culver City will be replaced by automatic trunk test frame at end of conversion job. Message ticketers (right) will be removed from the trunk circuits.

calls in the trouble recorder and a trouble card is punched. An MF receiver checks MF outpulsing from the sender.

The original lamp-type trouble indicator is too small to include trouble displays for the added AMA equipment. An auxiliary lamp-type indicator could be provided, but the cost of transcribing lamp records more than justifies the installation of a trouble recorder. This device can handle all trouble records for the modified system, so that the lamp-type trouble indicator is removed after conversion. Since the trouble recorder produces a record much faster, more complete trouble records will be obtained for detailed trouble analysis.

The completely automatic trunk-test circuit used to test AMA trunks replaces the original trunk-test circuit, Figure 5, in which manual operation permitted observation of both the ticketing mechanism and the ticket itself during the progress of a test. The printed ticket is now eliminated and the automatic test circuit provides significantly more efficient trunk testing.

Each automatic ticketing installation handles the short-haul toll traffic from a number of central-office units within a telephone building, up to a maximum of 10 units. At present, 22 such installations in the Los Angeles and San Francisco areas are to be converted to AMA operation. Culver City will be the first to be modified for AMA operation, and the proposed completion date is about the middle of 1957. The Mutual Building central office, one of the largest installations in Los Angeles, is scheduled for completion early in 1958.

The Pacific Telephone and Telegraph Company plans to arrange 24 additional telephone buildings in Los Angeles and San Francisco for AMA operation. Since these buildings do not now have automatic ticketing equipment, they will be equipped initially with the latest AMA circuits. The first such installation, in the La Brea Building, Los Angeles, was placed in service August 7, 1956. Over-all plans anticipate conversion of the 22 existing units and installation of the 24 new automatic message accounting units before the end of 1961.

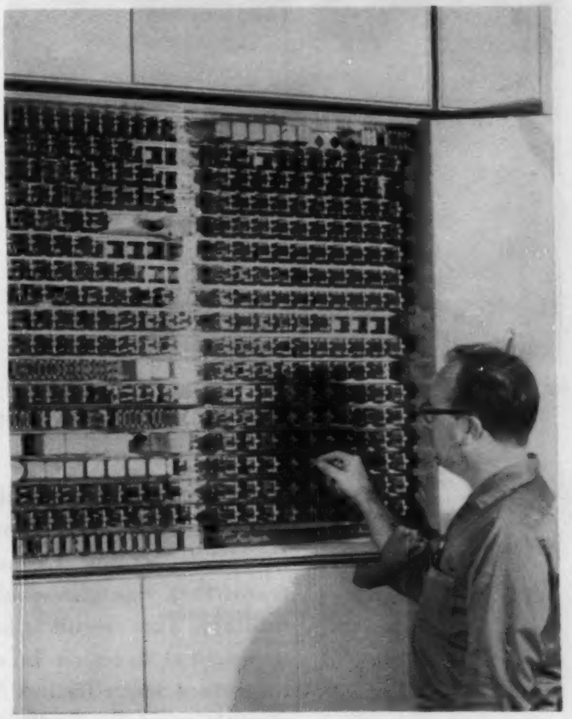
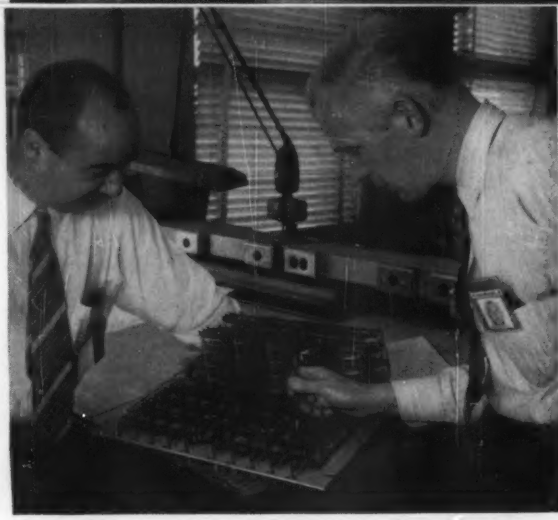


Fig. 6 — A switchman tests a sender at the La Brea central office.

THE AUTHOR

A. S. Martins joined the Laboratories in 1928 and completed the Laboratories student engineering course in 1932. In 1936, he joined the step-by-step systems laboratory testing group. During World War II, Mr. Martins took part in the development of electrical gun directors, and in the construction and testing of the early models of a submarine radar system. Since the war he has been concerned with the design of step-by-step systems circuits. He is now engaged in the development of centralized automatic message accounting for step-by-step intertoll offices. Mr. Martins received the B.E.E. degree from Brooklyn Polytechnic Institute in 1942.



A Transistor Gating Matrix for a Simulated Warfare Computer

W. H. MacWILLIAMS, JR. *Military Systems Engineering*

The transistor's two most important capabilities — switching and the amplification of electrical signals — were put to use almost immediately after its invention at Bell Laboratories. A circuit using the early point-contact transistors was incorporated into laboratory equipment designed for the military. This circuit is believed to be the first to use transistors to perform a practical function in operating laboratory equipment, and it made an important contribution in answering the question — how lethal are anti-aircraft guns in fending off an enemy attack?

This article describes what is believed to be the first working application of transistors. The early point-contact transistors (Type-A), announced by Bell Telephone Laboratories in 1948, were used early in 1949 to perform a circuit function essential to a laboratory simulated warfare computer developed in the course of a contract with the Bureau of Ordnance, Department of the Navy. The computer was called the Gunnery System Simulator, and was used to simulate the action of a warship's guns in fending off an enemy air attack.

The problem of assigning a warship's guns to the proper attacking airplanes is a complex one. As the individual aircraft approach a warship, they follow different flight paths and travel at different speeds. With high-speed planes, the tactical situation changes very quickly, and the plane that is now the most threatening may be superseded by another in only a few seconds.

A warship contains many groups of guns, and many controlling radars. Each gun group must have a radar to track its target, and a computer to predict the target's future behavior and calculate where the guns must fire for their projectiles to burst near the target. In practice, more than one group of guns can be fired from orders calculated by the same computer. To simplify this description, however, the combination of radar, computer, and group of gun mounts will here be considered an indivisible fire unit, and will be called a "director" for the purposes of this article.

Since each of a warship's directors can fire at only one target at a time, the ship must divide its directors among the attacking planes, sometimes assigning more than one to the same plane. After a director has shot down a plane, it must be reassigned immediately to another target.

In addition to this problem of the airplane's mobility, the job of assigning directors to targets is complicated by two factors. First, one doesn't know when a director will be free for another assignment, since the time until a target is shot down can only be predicted statistically. Second, the clear arcs of fire in a director (those not hidden by the ship's superstructure) change rapidly, since a ship under air attack usually maneuvers radically to avoid being hit. The whole situation changes so fast that even the best officer is hard pressed to assign the directors quickly and accurately.

The task of the Laboratories was to help the officer assigning directors to targets by developing equipment to compute and display information to help him make his decisions, and by studying various logics for carrying out the defense.

One obvious approach is to build experimental equipment suitable for installation in a warship, go to sea and test it, and make the indicated changes. The test program would require a great many mock attacks, because of the statistical nature of gunfire lethality, and conditions could not be controlled closely. A further difficulty is the great expense, since it would occupy many aircraft and ships with many men. Finally, it would be impossible to fly aircraft at the high speeds expected in the future. This inability to make the attack go fast enough is critical in testing a device designed to aid a human being, since the time-pressure on him is a vital part of the problem. It is clear that a seagoing test should only be the last phase of a program, because of its overriding expense and limited usefulness.

An alternative approach is to compute the statistical and human effects, and thus to design an effective equipment the first time. This approach was examined, but the problems were beyond the power of the available mathematical tools.

Accordingly, it was decided to build a simulated warfare computer, called the Gunnery System Simulator, which would enable arbitrary mock attacks to be flown against human beings equipped with laboratory-constructed aids. The simulator was designed to represent the statistical nature of gunfire lethality, and to keep score of the results. A given attack could be flown as often as required to obtain statistical reliability, and the aids could be tested with different observers under the same set of conditions.

The man being tested was at a console where he assigned directors to targets on the basis of information showing the threats of the targets and the present state of the directors. The behavior of

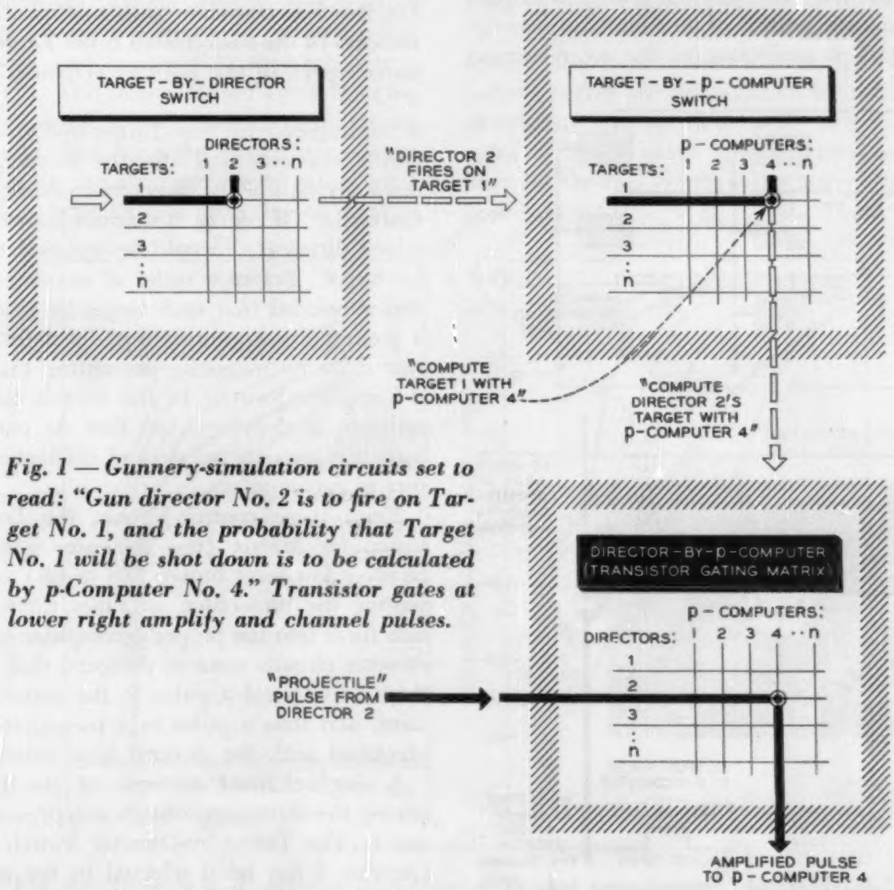


Fig. 1 — Gunnery-simulation circuits set to read: "Gun director No. 2 is to fire on Target No. 1, and the probability that Target No. 1 will be shot down is to be calculated by p-Computer No. 4." Transistor gates at lower right amplify and channel pulses.

future high-speed aircraft could be represented as desired. The simulator was thus the laboratory equivalent of being able to test proposed aids in extended tactical fleet exercises with gunfire, against targets expected to be available only in the future, and at comparatively low expense.

The Transistor Gating Matrix was developed to perform a function required for the Gunnery System Simulator, connected with computing the

lethal effect of individual projectiles fired from simulated guns against their simulated targets. The matrix was required to channel pulses corresponding to individual projectiles into appropriate circuits for computing kill probability. These circuits were called "p-computers," since "p" is the symbol used to represent the probability that a single shot would knock down the target. The p-computers permitted calculation of the number of targets shot down.

Broadly speaking, the Simulator resembles a pinball machine. In such a machine a ball bounces off the pins set in an array on the playing surface, and there is a certain chance that the ball will fall into any particular hole. The array of pins is analogous to the probabilistic portion of the Simulator, and the array of lights is analogous to the score-keeping

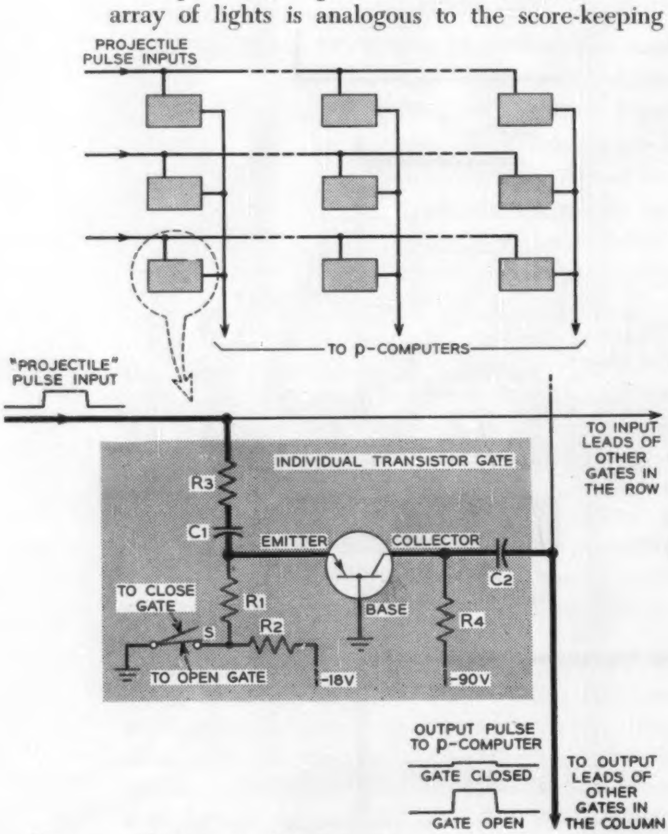


Fig. 3 — Schematic diagram of arrangement of gates (above) and individual transistor gate (below); switch S closes and opens the gate to "projectile" pulses.

portion. In this sense, the transistor gating matrix serves as a connecting link between the array of pins and the scoreboard.

The relation of the transistor gating matrix to the targets, directors, and p-computers is shown in Figure 1. The assignment of directors to targets

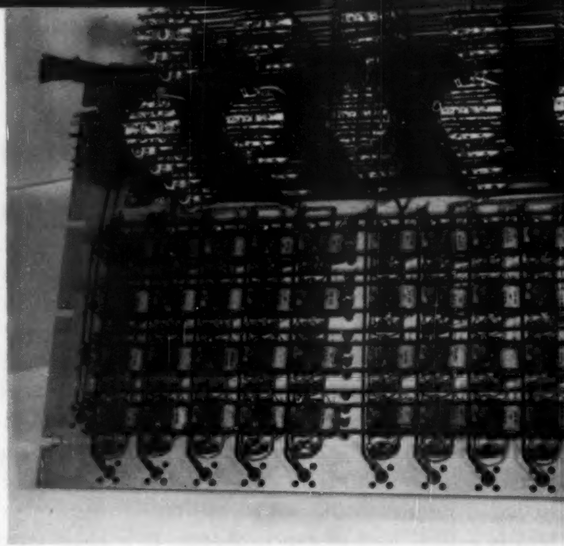


Fig. 2 — The transistor gating matrix. The array of switches in the background is the Target-by-p-Computer switch of the gunnery system simulator.

is represented by the Target-by-Director Switch, which was controlled either by an operator or automatically. All of the directors could be used simultaneously. Of course, it was not known in advance which director(s) would be assigned to a particular target. Before a series of simulated attacks, it was stipulated that each target be associated with a p-computer appropriate to its flight path. This was done by manually pre-setting the Target-by-p-Computer Switch. In this switch, the target coordinate is depressed, so that its output at any instant represents the desired connections of directors to p-computers.

From these control signals, the Director-by-p-Computer Matrix (the transistor gating matrix) receives low-level binary (on or off) pulses representing the projectiles, amplifies them, and channels them into the proper p-computer circuits. The director circuits were so designed that only one of them could send a pulse to the matrix at any instant, and thus a pulse in a p-computer could be identified with the director that initiated it.

A single-channel example of the relationships among the three components is represented in Figure 1. The Target-by-Director Switch shows that Director 2 has been selected to fire on Target 1 and the Target-by-p-Computer Switch shows that p-Computer 4 has been selected to determine the chance that any one projectile kills this target. The Transistor Gating Matrix then channels projectile pulses from Director 2 to p-Computer 4 as long as Director 2 is assigned to Target 1. The actual computer, of course, represented a number of simultaneous assignments great enough to be significant operationally.

In the term "Transistor Gating Matrix," the word *matrix* clearly indicates the two-coordinate array of rows of directors and columns of p-computers. The circuit is a *gating* matrix because the channeling is done by logical gates that either transmit (and amplify) an incoming pulse or reject it. Finally, the active amplifying and switching element of each gate is a Type-A *transistor*.

The Matrix consisted of 4 rows and 10 columns of gates (40 in all), as shown in Figure 2. The array of wired and ganged wafer switches seen in the upper part of the photograph is the Target-by-p-Computer Switch.

In describing the operation of an individual matrix gate, we will say that the gate is *open* when it is *transmitting* (as when a pretty girl comes through a garden gate), and is *closed* or *shut* when it is *nontransmitting*. The reader should avoid thinking of a gate as an on-off switch, since the words open and shut would then have the opposite meaning.

Figure 3 shows the arrangement of gates and a schematic of a single gate. The active element of the gate is a Type-A transistor whose base is grounded. The transistor is normally held in a non-conducting condition by a substantial negative voltage on the emitter. However, this bias voltage may be reduced to zero by making a ground contact with switch S, which in the actual circuit represents an extended network of relay contacts. The gate is open or closed according to whether S performs a grounding function or not. The input consists of 3-volt positive pulses of about 5 microseconds duration from the input lead, which is connected to the emitter through resistor R3 and capacitor C1. The output is developed across the load resistor R4, and consists of a pulse of negligible magnitude if the gate is closed (non-transmitting), or an amplified pulse of substantial magnitude if the gate is open (transmitting).

The characteristics of the circuit operation of the transistor may be seen from the two groups of curves in Figure 4. Figure 4(a) plots the Type-A transistor emitter voltage (V_e) versus emitter current (I_e) for different values of collector current (I_c). Figure 4(b) shows collector voltage (V_c) against the same values of emitter current, and various curves are again drawn for different values of collector current. Resistor R4 in the circuit has a value of 27,000 ohms, which determines the "load lines" in the two graphs – the heavy lines superimposed on the groups of curves. These lines define the operating point of the transistor for specific conditions. For example, in Figure 4(b) we see that if the emitter current is 0.5 milliampere, the intersection of this ordinate with the collector load lines shows the collector voltage to be about minus 31 volts and the collector current to be about minus 2.2 milliamperes.

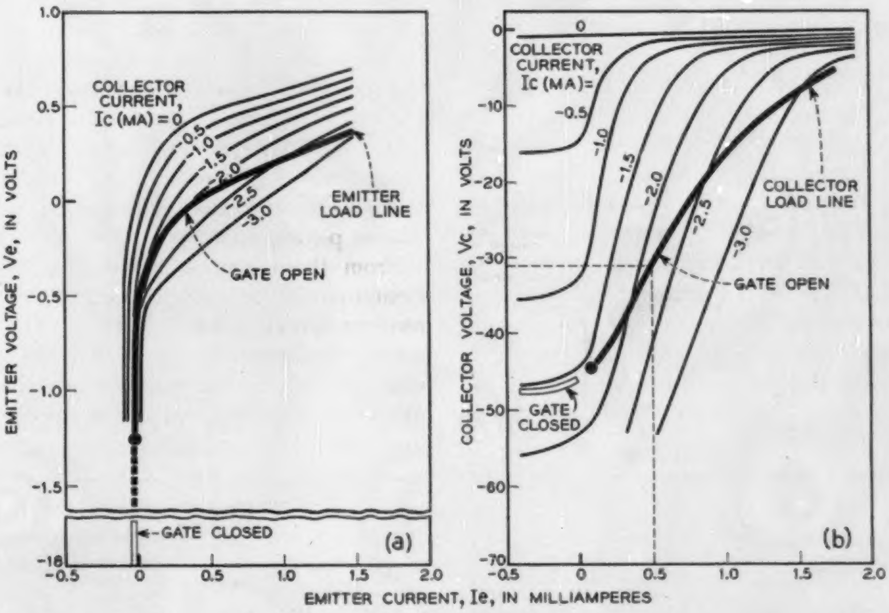


Fig. 4 — Emitter and collector load lines of Type-A transistor in gating matrix, showing open- and closed-gate conditions of each gate in the circuit.

In these graphs the collector resistance (which determines the output resistance of the gate) is measured by the vertical spacing between the collector-current curves. In the region of a collector potential of minus 30 volts, for instance, this spacing is seen to be fairly large, which means a relatively high resistance, while a lower resistance is indicated by the closely spaced lines shown at the top of the illustration.

The open- and closed-gate operating points are indicated on both load lines in Figure 4. The large negative emitter voltage of minus 18 volts used to render the transistor non-conducting is indicated at the lower left part of Figure 4(a). In Figure 4(b), the closed-gate portion of the load line is essentially horizontal, which shows that there is little change in collector voltage with a change in emitter voltage such as would be caused by an input pulse. In this region, the output resistance is high, about 20,000 ohms.

When the gate is opened by closing switch S, the negative emitter bias voltage is removed, and the emitter circuit now acts as a conducting diode. The operating point shifts off the closed-gate lines and passes to the left end of each of the gate-open parts of the load lines (as indicated by the heavy black dots in Figure 4). Then, when an input pulse appears at the emitter, the transistor conditions change to those at the right ends of the load lines. As seen from Figure 4(b), this means that the collector voltage rises from about minus 45 volts to a value near zero volts. In this region, the I_c lines are closely spaced, and the output resistance is therefore low, only about 3,000 ohms.

Let's consider the properties of this gating circuit which make it suitable to combine the gates into a matrix array. The input circuit resistance is high when the gate is closed. When the gate is open, the resistor R3 keeps the resistance seen by a pulse from being too low, and ordinarily only one gate is open per row. These two properties mean that an input pulse is not attenuated appreciably, even by a matrix of gates.

Turning now to the output circuit, we have already mentioned that when the gate is closed, the output resistance is high. Moreover, the output resistance remains high even when the gate is open, except when a pulse is being transmitted. That is, in Figure 4(b) the left end of the collector load line is still in the high-resistance region. When a pulse is transmitted, however, the transistor conditions change to the upper right or low-resistance region. For this reason, a number of such gates may be arrayed in parallel with little reduction of the amplitude of the output pulse.

As seen in Figure 2, a matrix of 40 gates was used in the simulator. The measured outputs of the gates (with an input of 3-volt, 5-microsecond pulses occurring at a 5-kc repetition rate) gave a maximum signal for a closed gate of 0.1 volt, and a minimum signal for an open gate of 16 volts, which represents a voltage discrimination of 44 db. In use, the matrix was quite successful. It was operated with the simulator for somewhat over a year and a half, and during this period only one transistor had to be replaced.

It is clear that a rectangular array of gates is also adapted to use when the inputs may appear simultaneously, although in this case usually only one output circuit is connected to a single input circuit.

The gates may also be used as linear amplifying gates by connecting the junction of R1 and R2 in each individual crosspoint to a moderately positive value of emitter voltage for the open condition.

THE AUTHOR

W. H. MacWilliams, Jr., received the degrees of B.E. and Dr. Eng. from Johns Hopkins University in 1936 and 1941 respectively. He joined the Laboratories in 1946, after five years' service in the Navy in research and development on anti-aircraft fire control equipment. His Laboratories work has included planning and developing military air defense systems, automatic decision-making computers, and laboratory equipment for simulating large weapon assignment systems. Since 1953 he has been in charge of a Sub-Department concerned with Military Systems Studies at the Laboratories.

The gate then operates along the linear portion of the load line in Figure 4(b). This connection suggests using the matrix for telephone conversations, and this was indeed tried with a rectangular 4 x 4 array, and found satisfactory on an experimental basis.

Speaking more generally, transistors and diodes are very well adapted for use in complex digital circuits such as occur in telephone central office switching and digital computers, for several reasons. First, they are solid state devices, which are potentially more stable than thermionic tubes, and also they have the advantages of smaller size and lower power consumption than either tubes or relays. Of the solid state components, the transistor shares with the diode its ability to perform the logical functions useful in digital circuits, and in addition, it has the ability to provide amplification. In many complex applications subsequent to the circuit described above, diodes have been used to provide the logical functions passively, and transistor circuits have been used to produce the required amplification (albeit with some diodes to ease the transistor circuit problems). However, in simple circuits like the one described here, the same transistor can be used to obtain both logical functions and gain.

The current trend has returned to circuits in which logic and gain are combined, with the direct-coupled transistor logic (DCTL) circuits, in which a high degree of dc stability makes the coupling circuits exceedingly simple.

Supermendur—An Improved Magnetic Alloy

Substantial improvements in magnetic amplifiers, switching and memory devices, pulse transformers, and power transformers are now possible as a result of a new magnetic alloy which has been developed at Bell Telephone Laboratories. This material will permit reductions in the size of magnetic components without any sacrifice in performance, and will facilitate the design of new components having greatly improved performance characteristics.

Called Supermendur, the alloy has a number of exceptional properties, including higher permeability and lower hysteresis losses at higher flux densities than any material heretofore available. The composition of Supermendur (49 per cent iron, 49 per cent cobalt and 2 per cent vanadium) is similar to 2V-Permendur, a magnetic alloy developed at Bell Laboratories many years ago. However, H. L. B. Gould and D. H. Wenny have improved the characteristics of the alloy to a remarkable degree. The hysteresis losses have been reduced by a factor of ten. Maximum permeability is now 66,000 at 20,000 gausses; remanence, 21,500 gausses; coercive force, 0.26 oersted; and saturation, 24,000 gausses. Core losses are less than 6 watts per pound at 400 cycles at a flux density of 100,000 lines per square inch. The hysteresis loop is rectangular with a flux swing of 45,500 gausses from minus remanence to plus saturation.

These outstanding properties have been achieved by using commercial materials of the highest purity, melting in a controlled atmosphere furnace, and subjecting the resulting alloy to a prescribed schedule of rolling and heat treatment in a magnetic field. The material is so malleable that it can be cold-rolled from 0.090 inch to 0.0003 inch without intermediate anneals and without losing its ductility.

Power transformer cores of 0.004 inch or 0.002 inch Supermendur tape can provide an output more than 30 per cent greater than comparable grain-oriented silicon steel cores, the best previously available material. Advantages on an ampere turn excitation basis are even greater percentage-wise. This permits a reduction in core size and weight of at least 30 per cent for the same output, a significant factor in many applications. Flux density can exceed 140,000 lines per square inch without excessive losses.

Characteristics of this material make it ideally suited for power transformers, pulse transformers, and magnetic amplifiers. The precipitous sides of the hysteresis loop indicate that the gain of a magnetic amplifier can be increased as much as 80 per cent over that obtainable with grain-oriented silicon steel. Other possible applications include telephone receiver diaphragms, and switching and memory devices. The material may be especially useful where miniaturization is desired, or where high temperature operation is contemplated.

The Western Electric Company does not plan to produce Supermendur for commercial consumption. A number of companies, however, have expressed an interest in the material and it probably will be manufactured by several of these companies under Western Electric license in the near future.

Suppression of Static and Radio Interference in N-Carrier Cables

J. L. LINDNER *Special Systems Engineering I*

Because a telephone circuit often uses a combination of open wire and a cable pair, noise on the open wire can be induced into other cable pairs by the phenomenon of secondary induction. When type-N carrier was applied to cable circuits, it was found to be very susceptible to secondary induction of both noise and radio interference because of its wide frequency range. To eliminate this, the Laboratories developed two special inductors. Connected between a cable pair and open wire at their junction, the inductors effectively suppress induced noise and interfering radio signals.

It has long been recognized that noise currents can be introduced into cables when some of the cable pairs are extended by open-wire or drop-wire circuits. The open wires act as a receiving antenna, picking up energy from numerous external electric fields and feeding it to ground through the cable pair. Noise currents in one pair then cause noise currents in other pairs in the cable. This effect, called secondary induction, has a large sphere of influence – that is, noise currents on a small number of conductors in a cable may create severe noise conditions on a large number of surrounding conductors.

Early studies of this problem were made in 1931 by the Department of Development and Research of the American Telephone and Telegraph Company, which later became part of the Laboratories. At that time, only voice-frequency circuits were involved and the usual source of noise was induction from power lines. Even so, lightning strokes and current surges in power lines paralleling telephone lines for any distance created differences of potential to ground on the telephone lines of several hundred volts. The resulting currents, although of short duration, often reached high values.

The mechanism of secondary induction can be understood from Figures 1 and 2. In Figure 1, lightning or some other energy source induces a voltage to ground on the open-wire line, which causes a current to flow through both wires of the cable pair in the same direction toward ground. This, known as a "longitudinal" current because it flows along the cable in only one direction, induces voltages and resulting currents in the wires of an adjacent pair, Figure 2. If the adjacent pair were perfectly balanced, the two currents would cancel. However, a slight impedance unbalance causes one current to be larger than the other and the net result is a current circulating in the metallic telephone circuit. Thus, longitudinal currents, which do

not themselves create noise, cause noise currents to be produced in telephone circuits.

Short-circuiting relay protectors,* developed to by-pass the longitudinal currents to ground and hold the induced voltages to low values, also helped to reduce secondary induction. However, with the

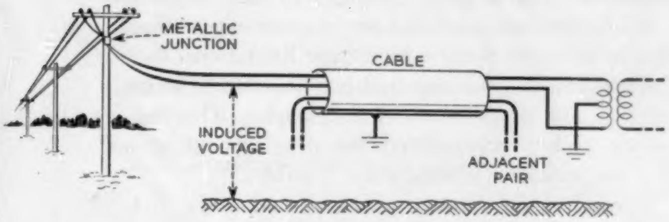


Fig. 1 — Induced voltage to ground on the open-wire portion of the line creates longitudinal currents in the cable pair.

advent of type-K carrier for cables,† the problem of secondary induction became more severe. Type K operates in the frequency range between 10 and 60 kc, and at comparatively low energy levels. Radiation and resultant induction at these frequencies is considerably more serious than at voice frequencies. Remedial measures consisted of special inductors inserted between cable and open-wire pairs at their metallic junction. Circulating (telephone or telegraph) currents pass through the inductor in opposite phases and are not attenuated. Longitudinal (noise) currents pass through the inductor in the same phase and are effectively suppressed. Reduction of the longitudinal current remaining in the cable pair results in reduced noise from any secondary induction into the carrier pair.

The first installation of N carrier,‡ between Milwaukee and Madison, Wisconsin, was subject to similar trouble. There were many open-wire and drop-wire extensions of non-N cable pairs between

* Record, *June* 1938, *page* 353. † *April* 1938, *page* 260.
‡ Record, *July*, 1952, *page* 277.

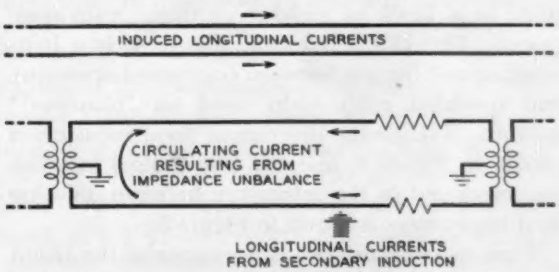


Fig. 2 — Longitudinal currents induced by secondary induction create an unbalance current when the line impedances are not equal.

Milwaukee and Madison. Radio interference from an air navigational radio range station at Madison, as well as noise during thunderstorms, was observed on telephone lines. Highly objectionable noise during thunderstorms was measured on an experimental program channel operating on N-carrier facilities. With the proposed use of N-carrier channels for special-service facilities – program, telephoto, voice-frequency telegraph, etc. – it was evident that adequate suppression of noise arising from exposure of the unsheathed conductors to radio and static fields would be necessary. Since the N-carrier system utilizes a different band of frequencies than the K-carrier system, a new suppressor having the required loss in the effective N-carrier band was needed.

Design of a device having adequate noise suppression for N cables was difficult because of the wide frequency band of the N system (36-268 kc) and because of the design of the high-low repeater associated with this system. The N-carrier system

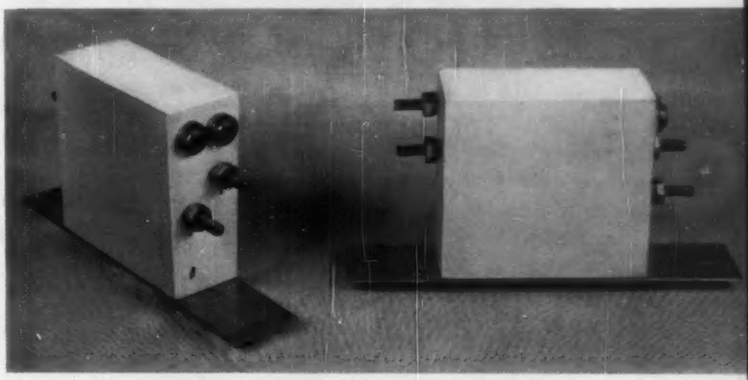


Fig. 3 — The 1530A inductor is a molded plastic unit.

transmits a low-group band of frequencies (36 to 140 kc) in one direction over a cable pair and a high-group band (164 to 268 kc) in the other direction over another pair in the same cable. At a repeater, the two groups are interchanged, or "frogged," so that the low group becomes the high group and vice versa. This is accomplished by a 304-kc modulating frequency in each repeater. Subtracting 36-140 kc from 304 kc gives a band between 268 and 164 kc for the low-high direction, and 304 kc minus 164-268 kc gives a band between 140-36 kc for the high-low direction. Thus, the change from high to low and low to high groups is accomplished by subtracting the line frequencies from the frogging oscillator frequency.

Unfortunately, unless special precautions are

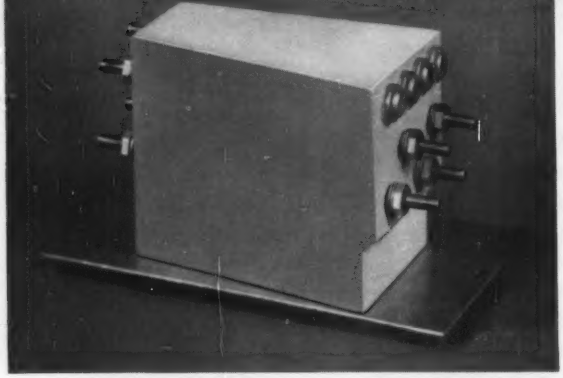


Fig. 4 — The 1530B inductor, used on phantom circuits, contains four coils in a molded plastic unit.

taken, the required low-band difference frequencies can also be produced by extraneous frequencies in a band above the frogging oscillator frequency by the right amount as well as by the wanted band at 164-268 kc. Noise or radio interference in the band between 340 and 444 kc, just below the radio broadcast band, can produce so-called "image" interference in the N-carrier low band. Since the N-system repeater does not include a "roof" low-pass filter,* noise in the high-band range (164-268 kc) and the image band range (340-444 kc) will be picked up and transmitted as low-band signals by a high-low repeater.

Obviously, if remedial measures similar to those applied to K-carrier systems were to be used, the inductors would have to achieve a satisfactory loss over the complete band from 30 to 444 kc. To determine the practicability of such a suppression technique, a trial of experimental narrow-band noise-suppressing inductors was held at Sunbury, Pennsylvania, during the summer of 1951 and at Annapolis, Maryland, during the spring of 1952. The Sunbury tests demonstrated that suitable inductors installed at junctions of cable and open wire could adequately suppress noise due to atmospheric static

* Later repeaters include a "roof" filter that reduces image response but has little effect on noise in the high-band range.

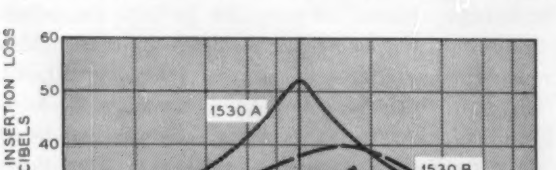


Fig. 5 — Plot of inductor characteristics shows that performance surpasses the design objective.

on channels of an N system operating on other pairs in the same cable. Two channels of all N systems operating in the Annapolis-Baltimore-Washington area had been turned down because of severe radio interference. The Annapolis tests indicated that with proper suppression devices all channels could be used.

While the narrow-band suppressors were effective in reducing noise within their limitations, they did not produce the required loss over the N transmission and image bands of frequencies. This deficiency in loss necessitated the development of a new suppressor specifically for N cables.

Guided by information obtained during the Sun-

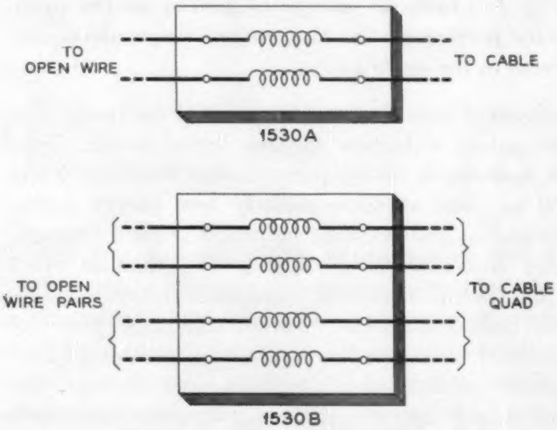


Fig. 6 — Schematic diagrams of the new inductors. Protectors on the open-wire side are not shown.

bury and Annapolis trials, design objectives were formulated for two new broad-band suppressors capable of reducing noise from open-wire or drop-wire pairs exposed to radiation or induction fields. The 1530A inductor, Figure 3, consists of a two-winding coil on a toroidal permalloy tape core and two 107B protectors, all assembled with the necessary screw-type binding posts and a mounting plate in a block of molded synthetic resin compound. The 1530B inductor, Figure 4, is a four-winding coil for use between transposed open-wire and quadded cable pairs used on "phantom"* circuits. A schematic diagram of these inductors is shown in Figure 6, and the longitudinal insertion loss measured in the laboratory between 360-ohm load impedances is shown in Figure 5.

Tests to determine the performance of the 1530A inductor under field conditions were conducted in

* A phantom circuit is a third telephone or telegraph circuit derived from two individual metallic circuits.

the Annapolis to Hyattsville, Maryland, N-carrier cable. The tests showed that sufficient longitudinal loss was provided to reduce 122-kc radio interference to satisfactory levels. The loss compared favorably with laboratory measurements of insertion loss.

The 1530A or 1530B inductor is inserted in the open-wire pair or customer drop wire at a point close to the cable-pair extension terminal. The built-in protectors are connected on the open-wire or drop-wire side of the suppressor to prevent lightning damage to the inductor. The suppressor adds little or no loss in the metallic circuit but presents a high impedance to the unwanted longitudinal currents. These new inductors are comparable in size to and less expensive than the existing inductors used on type-K cables.

THE AUTHOR

J. L. Lindner joined the Development and Research Department of the A.T.&T. Co. in 1930 and transferred to the Laboratories with that department in 1934. As a member of the interference prevention group he participated in field tests and studies of noise and crosstalk currents for open-wire and cable broadband systems. During World War II, Mr. Lindner worked on several projects for the Office of Scientific Research and Development as well as doing considerable work at the Eatontown Signal Corps Laboratories and the Patuxent River Naval Air Station. In 1955, Mr. Lindner transferred to the Special Systems Engineering Department where he is currently concerned with the satisfactory transmission of the SAGE data signal over existing Bell System facilities.

Patents Issued to Members of Bell Telephone Laboratories During December

Brown, C. B., Hampton, L. N., and Thiel, F. A., Jr. – *Card Translator* – 2,774,821.

Burton, J. A. – *Process of Fabricating Germanium Single Crystals* – 2,774,695.

Dunlap, K. S., and Lovell, C. A. – *Communication System* – 2,744,822.

Elliott, S. J., Thomas, F. M., and Worley, O. C. – *Driving and Breaking System for Reeling Mechanism* – 2,775,407.

Felch, E. P. – *Crystal Oscillator Apparatus* – 2,775,699.

Fine, M. E. – *Bodies Having Low Temperature Coefficients of Elasticity* – 2,775,536.

Friis, H. T. – *Transmitting and Receiving Circuits for Wave Transmission Systems* – 2,773,978.

Goodall, W. M. – *Amplitude-Sensitive Multistate Device* – 2,773,981.

Hampton, L. N., see Brown, C. B.

Harrison, H. C. – *Electrical Key* – 2,775,662.

Howson, L. – *Phase Shifting Circuit* – 2,774,872.

Israel, J. O. – *Frequency Controlled Oscillation System* – 2,775,701.

Jakes, W. C., Jr. – *Microwave Antenna System* – 2,775,761.

Kernahan, J. J. J., and Lozier, J. C. – *Digital to Analogue Converter with Digital Feedback Control* – 2,775,727.

Laico, J. P. – *Manufacture of Traveling Wave Tubes* – 2,772,939.

Lovell, C. A., see Dunlap, K. S.

Lozier, J. C., see Kernahan, J. J. J.

Mason, W. P., and McSkimin, H. J. – *Electromechanical Wave Filter* – 2,774,042.

Mason, W. P., and Thurston, R. N. – *Ferroelectric Recording and Reproduction of Speech* – 2,775,650.

Mason, W. P., and Shockley, W. – *Negative Resistance Amplifiers* – 2,775,658.

McSkimin, H. J., see Mason, W. P.

Melick, J. M. – *Electromechanical Translator* – 2,774,963.

Miller, S. E. – *Methods and Apparatus for Transmitting Circular Electric Waves in Wave Guides* – 2,774,945.

Oliver, B. M. – *Amplitude Sensitive Multistate Device* – 2,773,980.

Oliver, B. M. – *Directional Coupling Systems* – 2,775,740.

Rieke, J. W. – *Bridge Stabilized Oscillator* – 2,774,873.

Ring, D. H. – *Frequency Stabilized Oscillator* – 2,775,700.

Samuel, A. L. – *Transmitting and Receiving Circuits for Wave Transmission Systems* – 2,774,066.

Semmelman, C. L. – *Nonreciprocal Transmitting Devices* – 2,774,890.

Shockley, W., see Mason, W. P.

Thiel, F. A., Jr., see Brown, C. B.

Thomas, F. M., see Elliott, S. J.

Thurston, R. N., see Mason, W. P.

Worley, O. C., see Elliott, S. J.

One-Man Aerial Tent

Peak-roof wall tents are familiar sights along aerial telephone cable routes, for they protect men and equipment from the weather while construction and maintenance work is in progress. However, since many of these operations can be performed by one man, and since the peak-roof tent is too bulky for a one-man job, a new lightweight aerial tent has been provided for the Bell System.

This item, designated the "C Ladder Tent" is an adaptation of one that originated in the Illinois Bell Telephone Company. It is used in conjunction with the standard extension ladder, the upper end of which is suspended from the cable-supporting strand by a wire-rope sling. A small wood platform attached to the ladder rungs at a convenient height permits the workman to sit or stand between the cable and ladder within easy reach of the cable.

The tent has a collapsible frame of three flexible steel strand bows, attached at the ends to clamps for securing the frame to the cable suspension strand. Over this frame, a fire-, water-, and mildew-resistant canvas cover is sewed in place. The assembled tent, which weighs only 22 lbs., can be collapsed into a roll sufficently small to permit safe handling by one man.

In use, the workman first places the extension ladder with its associated support and platform at the desired location. Then, while sitting on the platform and secured to the strand by his safety strap, he hoists the collapsed tent by means of a handline and attaches the frame clamps to the suspension strand. Because of the flexible nature of the tent frame, the spacing of the clamps may be adjusted to provide suitable working space. After the frame clamps are tightened, the frame of the tent is opened and the cover allowed to drape from it. The two outer bows of the frame, being hinged to the clamps, fall to positions permitted by the cover, while the center bow, which is fixed in an approximately vertical position by the clamps, provides the necessary head room. The rear of the cover is draped over the upper end of the extension ladder, and the ladder thus provides additional support for the cover. To give stability to the erected tent, guy ropes attached to the bottom of the cover are tied to the ladder rungs. The side openings of the tent are closed by using interlaced rope loops provided for the purpose, and in cold weather the bottom of the tent can be gathered about the ladder by means of the rope running through the bottom hem of the rear apron. In warm weather the front apron of the tent can be rolled up and secured with short ropes running through grommets just below the front bow.

Side view of ladder tent, front apron raised.

To remove the tent, the workman unlaces the side openings, removes the guys from the ladder, and gathers the cover around the frame as it is collapsed. He then ties the tent in a bundle with the front guy ropes. Finally, he releases the clamps and lowers the folded tent over the strand to permit attaching the handline for lowering the tent to the ground.

E. L. ALFORD, *Outside Plant Development*

Modernized Line-Finder Units for Step-By-Step

A. S. KING *Special Systems Development*

Line finders, used in step-by-step offices to locate a calling customer's line and connect it to other equipment, consist primarily of step-by-step switches. In keeping with the Bell System policy of utilizing the most modern apparatus and the latest manufacturing techniques, the associated relays, jacks, fuses, and other apparatus have been relocated on a smaller, less expensive mounting framework. The result of this modernization program is that four basic line-finder codes can now replace a total of nineteen previous codes.

The prevailing high production level for step-by-step dial equipment is a singular aspect of system-wide efforts to meet unprecedented demands for telephone service. Naturally, perhaps, some diminution could have been expected in the production of older dial systems, such as step-by-step and panel, as manufacturing programs for the more modern crossbar dial systems gained momentum. Prodigious as these latter programs have been, tremendous customer demands, the expansion of direct distance dialing, and widespread conversion from manual to dial operation, have required that virtually all facilities for the manufacture of step-by-step equipment continue to operate at maximum capacity. This sustained demand for step-by-step equipment made it desirable to redesign certain portions of the central-office equipment, to utilize modern apparatus to the best advantage and to inject the latest manufacturing techniques for fabrication and wiring. A typical example of this modernizing procedure is the line-finder unit.

A line finder may be considered as the "front door" to a dial central office since, when a customer lifts the handset to initiate a call, the line finder locates the particular calling line and connects it to subsequent switches that are in readiness to receive the dialed digits and route the call to its destination. Existing line-finder units, Figure 1, were designed more than 25 years ago when the step-by-step machine-switching system was expanding the field of dial operation in the Bell System. They were made available in three different sizes, accommodating 16, 20, or 30 line-finder switches, to provide the necessary flexibility for traffic requirements. Each size of unit was arranged with either 3 or 4 multiple banks of contacts to care for various classes of service. In addition, each unit contained relays for 200 customer lines.

These early units, intended only for the larger central offices, were designed in an era when frame space, floor space, ironwork, and materials in general were not nearly as expensive as they are today. Subsequently, when small unattended dial offices were developed for rural communities, the original

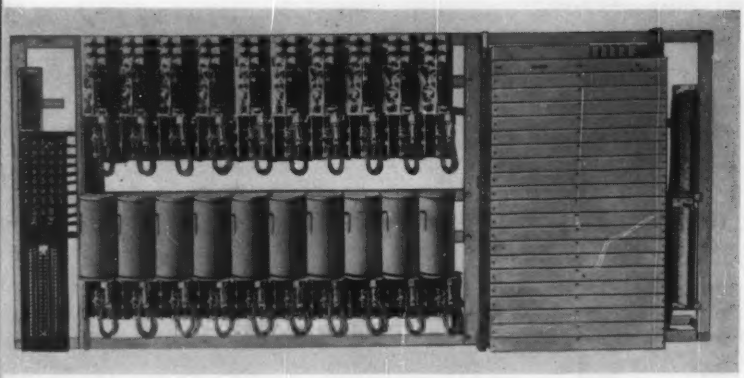


Fig. 1 — A typical line-finder frame of the older design showing excessive space requirements.

units were supplemented by an entirely new series of line-finder units for the 355A dial office.* All told, a total of 19 standard line-finder codes are presently furnished by the Western Electric Company. In addition, three different widths of switch frames, all 11 feet, 6 inches high, are furnished for mounting the units in the larger offices while a fourth switch frame, 9 feet high, is used for the smaller offices. The three larger frames are suitable for mounting line-finder units only but the smaller frame, widely known as the "universal switch frame," is used for mounting all types of switches, including line finders, in a 355A office. This permits complete flexibility in equipment layouts for the most economical floor-plan arrangements.

In addition to the foregoing differences, which are purely physical, the existing line-finder setup is further complicated by fundamental circuit variations. These were introduced in the units for the 355A dial office, to reduce prices sufficiently to make it economically possible to extend dial telephone service to rural areas. For example, units for the larger offices employ the conventional two-relay (line and cutoff) line circuit whereas those for the smaller offices use a single two-step relay frequently referred to as a combined line and cutoff relay. In the larger units, each individual line-finder switch uses relays that control such functions as vertical and rotary stepping. As many as ten finders can be started searching for calling lines simultaneously. In the 355A units, the individual relays are omitted and the switches operate in sequence under control of a common allotter circuit. Not more than two finders can hunt simultaneously and this, of course, can have an effect on the hunting time.

Simplification of this elaborate line-finder setup was precipitated by the program for using longer customer loops. Application of this important economy measure was limited in areas served by 355A offices because the combined line and cutoff relay lacked the capabilities necessary to operate satisfactorily with longer loops.

Accordingly, it was decided to abandon the single-relay line circuit and use the two-relay line circuit in all cases. This would require increasing the over-all size of the 355A units, however, which in turn would prohibit the preferable layout of units on the switch frames for the most economical cabling and floor-plan arrangements. Consideration naturally turned to using the same line-finder arrangement for the smaller 355A offices that is used for the larger offices, to save the space occupied by the allotter equipment. Basically, such a move required that the various components of the typical large unit shown in Figure 1 be concentrated sufficiently to fit on the smaller universal switch frame without increasing the height of the unit. The result of this development effort is the new modern unit, Figure 3, which can be used in either a large office or a 355A office.

Not only does the new smaller unit provide the two-relay line circuit required to pave the way for loop extension on all lines in 355A offices but, of far greater economic importance, it reduces the line-finder frame and floor space requirements for the larger offices by about 20 per cent. In addition to this 20-switch unit that can be equipped with either 3 or 4 contact banks, two other units of similar design and construction have been made available.

* Record, *June*, 1941, *page* 316.

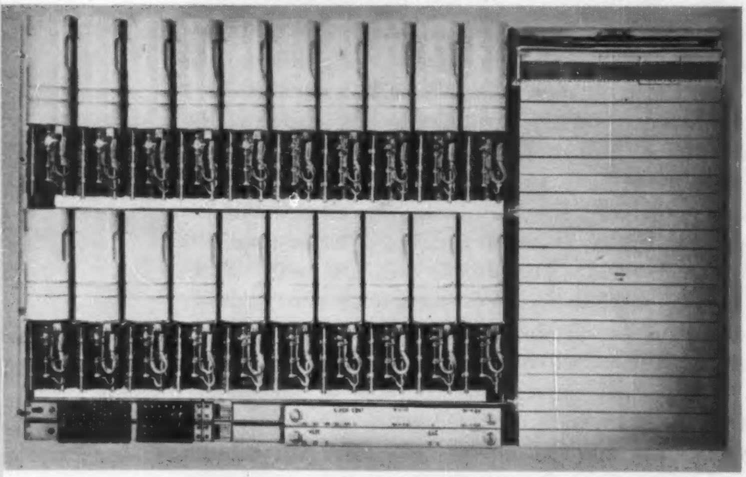


Fig. 2 — The modernized line-finder unit showing how space was conserved by rearrangement of component parts.

One is a 30-switch, 3-bank unit for use in areas where unusually heavy traffic must be handled. The other is a 20-switch unit with a special feature that may be furnished on any desired percentage of the lines served by the unit for locking out of service a line on which a permanent-signal trouble condition has occurred. A line in trouble is thus prevented from unduly holding a line-finder and selector switch out of service. This unit is for use only in 355A offices; these offices normally do not have a maintenance man in attendance.

The mechanical problems attending this development are of general interest from the design standpoint. At the outset, the over-all dimensions were irrevocably fixed. The unit had to be no wider than the existing universal switch frame to permit mounting it on the same frame with other units already designed to that width for the 355A office. In height, it was mandatory that it be possible to mount three units on a frame 11 feet, 6 inches high. These limiting dimensions appeared prohibitive in the early stages of development.

Since a line-finder unit is rather large and weighs approximately 600 pounds, the physical framework on which the equipment is mounted must be fairly substantial to meet handling and shipping requirements. However, when the two principal equipment components – the line-finder switches and line-circuit relays – were mounted in the usual manner, less than 1 inch of space was left for the vertical members of the unit framework assembly.

No bold stroke could clear this initial hurdle, but eventually the cumulative effect of a number of lesser design steps did bring forth the necessary additional space. As a first step, the mounting plate for the line-circuit relays was shortened from the customary 23 inches to 21⅜ inches. This space saving resulted from using a new guide for positioning the common cover. The new one-piece cover guide, secured by the mounting screws of the adjacent relay, not only saves space but eliminates a variety of small parts previously required. This single innovation indicates the magnitude of production involved, since it alone eliminates a total of over 7 million parts annually.

By utilizing the space pared from the line-circuit mounting plates as meagerly as possible and augmenting it in every conceivable manner, a new unit framework assembly was evolved. It bore little, if any, resemblance to its predecessor. A number of structural members had been eliminated by making other parts do double or even triple duty, and formed sheet-metal parts had been substituted for heavier standard structural shapes. The new framework was substantially lighter in weight but amazingly rigid, and subsequent laboratory tests have indicated that it is actually stronger.

Now, if the remaining auxiliary equipment components could be fitted within the confines of the new unit framework assembly, the battle was won. Each, in turn, was examined to determine if it could be eliminated or reduced in size. The line finder switches have always been individually fused but it was found that one fuse for two switches would be adequate – ten fuses were dropped out. A terminal

Fig. 3 — The new design permits simple, efficient cabling and uses available space economically.

strip was eliminated by terminating the outgoing switchboard cables from first selectors or trunks directly on the line-finder switch jacks. This is now the accepted practice for virtually all switch shelves or units of the universal type.

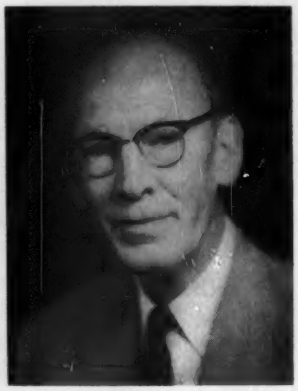
Since space requirements for terminals made solderless wrapped connections necessary, a new cast-resin terminal strip, which could be mounted horizontally and accommodate the required 800 leads from customers' lines in a minimum of space, was requested from the apparatus designers. The ensuing 252-type terminal strip not only saved space but contributed to the cost reduction by reducing the size of the unit local cable. It also provided an ideal wiring condition, with the heavy concentra-

tion of leads traversing the shortest possible route from the terminal strip, through the line circuits, and thence to the switch banks. These refinements and savings were further augmented by reducing the gauge of wire from 22 to 24 except for a few battery and ground feeders.

Despite all the foregoing moves, a shortage of space still persisted. To gain the final square inch, an asbestos composition fuse and jack panel was disposed of and the associated apparatus distributed more advantageously and economically. The 35-type or "grasshopper" fuses were replaced with new alarm-type cartridge fuses (70-type) that can be arranged with individual mountings on conventional apparatus mounting plates. A little space was saved. The test jacks that had previously been concentrated on the fuse and jack panel were relocated by placing each jack directly on its associated switch. This could not be accomplished by moving the jack bodily to its new location since there was not sufficient space to receive it. However, inasmuch as these were dual-purpose jacks, the functions could be segregated – a small 570-type key was used for the make-busy feature and the routine testing feature was taken care of by adding extra springs to an existing monitor jack on each switch. This expedient also contributed a small bonus from the maintenance standpoint, since the self-contained make-busy keys are somewhat more convenient than external plugs.

With the final hurdle cleared, the long-standing dream of a universalized line-finder arrangement for a large segment of our step-by-step dial network became a reality. Not only are considerable annual savings anticipated from the new streamlined facilities but, since they take cognizance of current traffic requirements, it is expected that they will serve the needs of the system better than the wide variety of units they replace. They represent a significant stride toward ideal assembly-line operation in which large quantities of equipment can be produced prior to receipt of the customer's order.

THE AUTHOR



A. S. King received an M.E. degree from Lehigh University and joined the Laboratories in 1928. He has been closely identified with the design and development of step-by-step and crossbar dial switching equipment for central office and PBX applications with particular emphasis on the economical introduction of these systems as unattended community dial offices in rural and suburban areas. Specialized endeavors have included the development of centralized testing facilities for the L1 carrier system and a unique PBX equipped with Braille characters that permitted its operation by a blind attendant. During the War, he participated in the development of Air Raid Warning facilities for both civilian and military use, portable radar systems for invasion purposes, airborne communications centers and radar test sets. Mr. King is a member of Tau Beta Pi.

New Solid-State Oscillator for Microwaves

The first successful operation of a completely new solid-state device which will oscillate at microwave frequencies has been achieved at Bell Telephone Laboratories by Derrick Scovil, George Feher and Harold Seidel.

The idea for this new electronic device was first proposed by Professor N. Bloembergen of Harvard University, in a recent paper in *The Physical Review*. Its theory was described by him recently at a meeting of the American Physical Society in New York City. The idea was also conceived and was enlarged upon by Mr. Scovil.

Dr. M. J. Kelly emphasized the significance of the new device in an address before the annual dinner meeting of the American Physical Society. The device, which might be called a spin oscillator, will also operate, in principle, as an amplifier. This development marks another significant advance arising from research in solid-state physics at Bell Telephone Laboratories.

One of the outstanding characteristics of the new device is that it is expected to have very low noise compared with conventional microwave devices. Thus, in theory, it could markedly extend the range of radio astronomy and could result in radically new long-distance communication systems to carry television programs and telephone calls across the continent.

The experiment demonstrating the operation of the new devices was performed at the Laboratories in Murray Hill on November 27. At that time, Messrs. Scovil, Feher and Seidel, using a crystal containing a small amount of a paramagnetic salt, produced continuous oscillations at 9,000 megacycles with a power output of about 20 microwatts.

Thus, a completely new source of microwave power operating under new physical principles was demonstrated, and scientists believe it is only a question of time until microwave amplification can be obtained employing such crystalline materials and operating under the same physical principles as the oscillator.

Although this experimental result is completely new, the possibility of such an occurrence has been the subject of studies and speculative discussion by a number of physicists for some time. The development represents the first successful application to a solid-state device of a relatively new principle, which has been called the "maser" principle. "Maser" was first demonstrated for molecular beams in gases in 1954 by Professor C. H. Townes and his collaborators at Columbia University. They coined the word "maser," which stands for "microwave amplification by stimulated emission of radiation." Recently there has been steadily increasing excitement among physicists, who have been trying to apply the "maser" principle to solids. Combrisson, Honig, and Townes at *Ecole Normale Superieure* in Paris, attempted one such application, which was partially successful.

This device, which is still in an early research stage, is expected to have novel and useful characteristics. Because it operates with electron spins in a paramagnetic crystal, theory predicts that it should have very low inherent noise compared to ordinary electronic oscillators or amplifiers which depend on the motion of charged particles at high temperatures. Therefore, it may be possible to amplify extremely weak radio signals — signals which may be several hundred times weaker than those usable at present.

Potentialities appear to exist for useful and novel microwave devices operating in the centimeter and millimeter wave region, although these experiments on a solid-state device are still in a very early research stage. As an amplifier, it should have a bandwidth of the order of 100 megacycles. Also, it should be tuned easily since its frequency is proportional to an applied magnetic field.

Preliminary theoretical estimates indicate that a noise figure corresponding to thermal noise at perhaps 5 or 10 degrees Kelvin should be attainable. This is hundreds of times better than is now available with conventional microwave circuitry and if realized in practice will open wide new vistas in the microwave field.

Harold Seidel, Derrick Scovil and George Feher, left to right, with microwave apparatus used to test the solid state devices in a strong magnetic field.

Dr. Kelly Addresses the American Physical Society

"The physicist of today lives and works in the midst of the fast moving currents of our society and, like it or not, the ivory towered existence is no more," Dr. Mervin J. Kelly declared recently in an address before the American Physical Society. "Today the physicist participates at the policy making level in the problems of our society, and the new knowledge derived from his researches is front-page news in our daily press."

Dr. Kelly spoke on "The Work and Environment of the Physicist – Yesterday, Today and Tomorrow" at the annual dinner meeting of the Physical Society in New York City on Feb. 1.

The physicist's new role results from the steadily increasing importance to society of the discoveries and researches of the physicist, as well as the rapid impact of this new knowledge upon social and economic problems.

Russian Science

"The dynamic policies of Communist Russia in the postwar period have accelerated this trend," Dr. Kelly said. "To build its military and industrial strength rapidly, Russia has placed great emphasis on science and technology. Our country, as the leader of the free Western World, has also emphasized selected areas of science and technology to best insure that, through maintenance of our superior strength, warfare and communist world domination be prevented. Physics, as perhaps the most rewarding science for this purpose, is at the very spearhead of our nation's effort to increase its economic and military might."

In the current effort to maintain our leadership in the economic and military spheres, nuclear science and technology play a leading role, Dr. Kelly pointed out. Because of the compelling importance of nuclear phenomena to warfare and to the peacetime economy, our government has assumed the direct responsibility for a large part of the science and technology.

"It is my conviction that the program has been, over all, admirably administered," he said. "A good balance has been maintained between basic science and technology. The progress in basic science, military and peaceful applications has been phenomenal. We have maintained world leadership. This has been made possible by the capacities of our scientists and technologists, the large financial support provided by government, largely through the Atomic Energy Commission, and the wisdom shown in the organizational patterns in which the work is done."

"Russia has also given large financial support and emphasis to nuclear science and development," Dr. Kelly continued, "and has developed much competence in them. There is evidence that Russia may, temporarily at least, surpass us in the pure science area. A recent study of the financial needs of our research in this area – perhaps the most challenging and important at the frontier of physics – indicates that the construction of the required ultra-high energy machines and the research programs employing them will, within five years, require annual expenditures reaching about ninety million dollars, approximately twice the present annual rate."

Atomic Energy

"The programs in peaceful applications of atomic energy have also made great progress," Dr. Kelly said, "and there is increasing participation, with their own funds, by interested industry. We have now arrived at the point where very large expansion of nuclear science and technology in industry can be foreseen. The rewards to our society and to the industries will be of huge proportions. Basic and applied physicists, in large numbers, will be required to staff these programs. Industry must build a capacity in basic research in nuclear science as well as in the technology of the many areas of application. This gives promise of becoming the most rapidly growing area of research and development in industry during the next decade or so."

In other areas of science and technology, including both military and civilian programs, the contributions of physicists have been so great that the

demand is now much greater than the supply. This is also true for other scientists and for engineers entering development, he said.

"There is no question of the compelling value to our culture of physics, as well as of all science," Dr. Kelly declared. "The training to and beyond the doctorate level of an adequate number of physicists is essential to our economic and military strength, but our society is not providing adequate financial support for this need.

"Despite these unfunded needs, we must not be blind to or lacking in pride of the great progress of the past decade. We have trained – and trained well – more physicists to the doctorate level in these ten years than in the previous fifty. Research in physics in our academic institutions has increased greatly in amount and has comprised a growing fraction of the additions to knowledge of all the physicists of the world.

"The academic community is, and must continue as, the primary source of progress in basic physics, as well as the place for training the ever-growing number of physicists that our nation must have if its culture and its way of life is to endure."

Physicists in Industry

In discussing the remarkable growth in industrial research and development during the past decade, Dr. Kelly pointed out that in 1954 about 60 per cent of the nation's physicists were in the laboratories of industry. A large fraction of them, in common with almost all physicists in military laboratories, are working in applied physics or development and not in basic physics. In our present technical education pattern, the presence of significant numbers of physicists and other scientists in applied areas of research and development is essential. Engineers, who occupy a large majority of the nation's professional positions in development have, in general, inadequate training in science to carry the full development responsibility.

"However, it is contrary to the best interests of the nation's progress in science and its application for so large a fraction of its deeply trained physicists to be lost to basic physics, even though they are highly productive in the applications area," Dr. Kelly said. "A change in the pattern of our engineering education that provides deeper training in science with a significant fraction of engineers trained to the doctorate level, and all with a minimum training period of five years, will lessen the need for physicists in development work.

"While there is basic physics work of excellent quality in some industrial laboratories," he continued, "its amount has increased all too slowly in this decade of rapid expansion of applied physics. Since there is national need for a larger volume of research in basic physics, and since it can be of large economic value to corporations, we can reasonably expect that basic physics in industrial laboratories will rapidly increase during the next few decades."

Because of the relatively small amount of research in basic science in industry, there are many who hold the view that industry cannot provide a stimulating environment and lifetime careers in basic research. This view is refuted, Dr. Kelly said, by the history of the few industrial laboratories that have maintained significant programs in basic research over a long period of time, for example, Bell Telephone Laboratories and the General Electric Company.

"This dedication to basic research at Bell Laboratories has been most rewarding to the Bell System and to our society generally," Dr. Kelly declared. "The application of the new knowledge obtained by the Laboratories from its researches in physics, and those in chemistry and mathematics as well, has been the central element in the Laboratories' large contributions of the past 40 years to communications technology.

"I am, therefore, on very firm ground in my assertion that basic science can thrive in industry and is most rewarding to it as well to our society. I am confident that its area will expand greatly in the decades ahead and that industry in time will make contributions to basic science in amounts comparable to those of the academic world.

Future of the Physicist

"Looking to the future, there is increasing need for the physicist in basic physics in our society, and with the changes I have mentioned in the educational pattern of the engineer, the need for physicists in development should become relatively less. The academic world will continue to be the physicist's place of origin and his most stimulating environment. Industry, however, will provide an ever-expanding area for careers in research in basic physics. While the environment cannot be made in every respect as attractive as that of the university, it can be made so nearly the equivalent that a happy, stimulating and productive life in basic physics can be foreseen for the ever-growing number of physicists whose careers will be in the laboratories of industry."

A.T.&T. Issues 1956 Annual Report

In the 1956 annual report issued recently, Frederick R. Kappel, President of the A. T. & T. Co., said that earnings of the Bell System in 1956 were equal to $13.16 a share of stock compared with $13.10 in 1955. The 1956 earnings were on 57,423,000 average shares outstanding, an increase of 6,717,000 from the average number of shares in the previous year. Bell System earnings on total capital were 6.8 per cent, the same as in 1955.

The A. T. & T. report was mailed to about 1,500,000 share owners, nearly two and a half times as many as those in any other company. It summed up a year of record financing and construction by the Bell Companies. The Bell System spent more than $2.2 billion for construction last year and will need to spend more in 1957, Mr. Kappel said. "In these times of unprecedented growth, with the need to obtain billions of dollars of new capital from investors, earnings above the present level are required." Increases in telephone rates are needed in many areas, he said.

"Right now, in common with all other business, we are experiencing higher costs of operation, including higher wage costs. We cannot escape this, for we must have able people and pay to get them. We have continuously better equipment and operating methods, but the costs that arise from inflation are much greater than these savings."

The report included a number of statistics which indicated the progress of telephone service during 1956. For example, the Bell System added 3,227,000 telephones – almost as many as the record gain in 1946. By the end of the year, the number of Bell Telephones in service was nearly 49,500,000. Also, long-distance conversations were up nearly 10 per cent over 1955. Some 11,000,000 customers can now dial nearby cities and towns directly, and 2,700,000 can dial as many as 20 million other telephones all over the nation. In addition, since the opening of the transatlantic telephone cable last fall, calls to and from Great Britain have nearly doubled.

The annual report indicated that, "Western Electric's production for the Bell System was the largest in history and Bell Telephone Laboratories has stepped up research and development programs which will contribute greatly to telephone progress in the years ahead." President Kappel cited a number of new telephone services under development. He said, "We are testing a simple new home communicating system. This will offer new convenience in answering calls, or in talking from room to room. Also a person in the house will be able to talk from any telephone with a caller at the door, through a small loudspeaker. We are also developing a new telephone of a design especially suited for use in bedrooms.

"We have other telephones for noisy locations, so that people talking on the telephone will not be bothered by room noise. Still another instrument that will soon be available is designed for talking in a very low voice. With this, in a quiet place like a library, one can speak in little more than a whisper. For railroads, new teletypewriter equipment will automatically relay information on the make-up of freight trains. With the enormous expansion of aviation, we are experimenting with microwave radio to carry radar signals for air traffic control, and developing new equipment for the air lines' own communications.

Each year we are developing more flexible communications for small business as well as for large. A brand new dial system for small organizations is now being tried out. It is small in size itself, can be installed quickly and has many convenient features. For instance, it will automatically connect incoming calls to a busy telephone as soon as the line is free. In another new system, as many as 36 telephones can reach each other without calls having to go through the regular switching equipment.

At Bell Laboratories, development of the new electronic switching system is going full speed ahead. We are sure this will lead to many improvements in service and also to greater efficiency. The first service trial is scheduled to start in Morris, Illinois, in 1959.

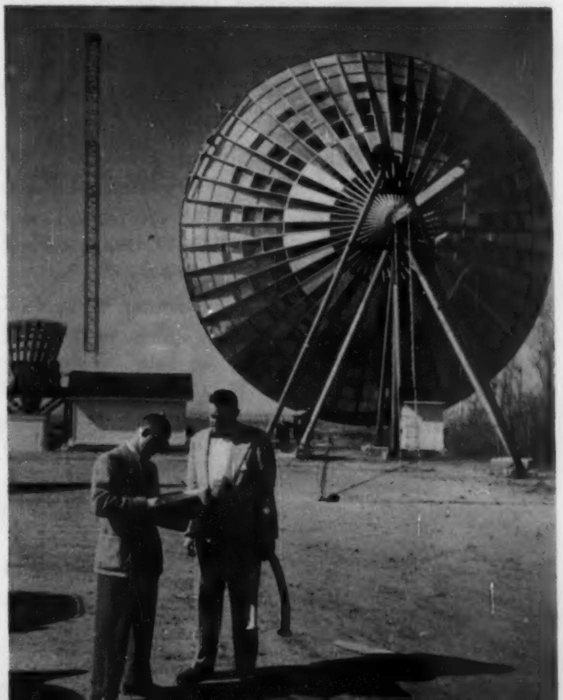
This year we expect to begin using a new high-power radio system for telephone service between Florida and Cuba, in cooperation with the telephone company there. This system can transmit up to 200 miles without relay stations. It may prove suitable for carrying television programs also.

The Laboratories is also trying out a new microwave radio relay system. This is economical for carrying telephone conversations or television over distances of 100 to 200 miles. Another system that is now under development in the Laboratories will be able to carry four times as many conversations as the radio relay systems that are in use today across the continent.

This year we shall test out a method for sending several conversations at the same time over local telephone wires. This will be done in very fast pulses — more than a million a second. Transistors and other miniature apparatus will keep the pulses accurate. The tests will be made over wires interconnecting central offices in a large city — "exchange trunks," we call them. This may well be the start of multiplying local voice paths on existing lines as we now multiply long-distance paths. It holds tremendous promise for the future.

Communications facilities for use by commercial airlines are being developed at the Laboratories.

Antenna at the Holmdel Laboratory used to study scatter propagation.



Telephone progress in large measure grows out of new systems, new devices, new structures, new concepts, new physical principles, new materials. At Bell Laboratories, research goes to the heart of the matter and builds out from there. And sometimes the result of a fundamental study may be far more important than it is spectacular.

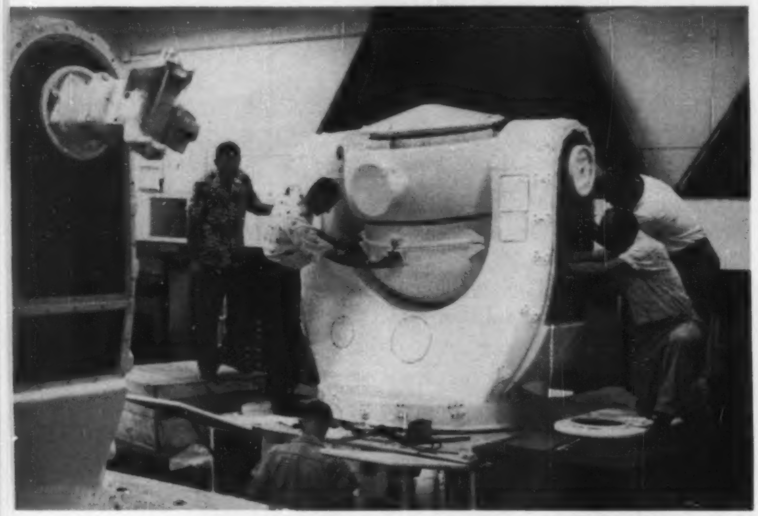
For example, thousands of miles of telephone cable have an outer covering of polyethylene. It is a fine, tough, durable material. But light affects it, and so does oxygen in the atmosphere. To protect against light, we add carbon black. To protect against oxidation, we add another chemical. But until recently, chemicals used for this purpose have lost some of their effectiveness in the presence of carbon black. The problem was to find new chemicals which would not have this weakness.

Now this problem has been solved. New ingredients have been discovered which actually work better with carbon black than without it. The result should be to lengthen the life of polyethylene

sheathing and increase the studiness and dependability of telephone cables.

As you know we do a great deal of work to help in the national defense. We did more in 1956 than in any year since World War II. The times require it and the Government looks to the Bell System to take assignments for which we are specially qualified.

The very growth of the telephone system makes it an ever stronger national bulwark. And we always keep defense considerations in mind as we plan and build new routes to meet general needs. This often requires special construction to insure that emergency services will be maintained in event of war damage. Work is also going right ahead on the SAGE air defense system which will tie radars and weapons together through a chain of electronic computing centers. This will use great quantities of interconnecting circuits supplied by the telephone companies.



Guided Missile control systems form an important part of the Laboratories work for the Armed Services.

On work of this kind we cooperate closely with the non-Bell telephone organizations, as we do in our merchandising efforts, in extending direct dialing, and in meeting many other problems. The fine relations throughout the industry are important to defense and to all telephone progress.

Bell Laboratories last year continued to work on military communications, guided missiles, and new electronic devices needed for defense. It is also taking a major part in developing guidance systems for the Air Force's intercontinental and intermediate-range ballistic missiles. Western Electric produced Nike missile systems in quantity and also began production of new Nike systems that have a much longer range. Building construction on the Distant Early Warning Line has been nearly finished and installation of detection and communications equipment will be completed on schedule this year. In Alaska, the first section of the "White Alice" communication network was turned over to the Air Force late in 1956. When completed in 1958, this system will link Alaskan defense outposts and cities across a distance of 3,100 route miles.

The report also stated that, "Our business and service and physical plant have grown more in the postwar years than in all the years before. This could only be done by employing much new capital, both equity and debt. Still it is worth noticing that the larger part of all our equity capital has been obtained through offers to share owners during this period. While receiving regular dividends each year, share owners have also had frequent opportunity to increase their investment on favorable terms. At the same time, taking the postwar period as a whole, we have maintained a sound financial structure, kept our indebtedness at a reasonable level, and strengthened the share owners' position through a moderate increase in the retained earnings which help to protect each share of stock."

Share owners last year received valuable rights which entitled them to subscribe for one new share at par, $100 a share, for each 10 shares held, Mr. Kappel said. Some 5,715,000 shares, 99.8 per cent of those offered, were purchased. More than one-half of the share owners used their rights to buy stock and bought more than two-thirds of the issue. "The average market value of the rights was $6.93. This is the eighth time since 1946 that our share owners have had rights to subscribe to new securities. The market value of such rights for each share has totaled about $22."

In 1956, the Bell System added 41,000 employees, for a total of 787,000. More than 115,000 of these employees have been with the Bell System for 25 years or more. Some 345,000 have served less than 5 years.

"But whether they are old or young in experience, the part they take in their communities and their skills, spirit, and understanding of what telephone users expect of them, are the greatest asset we have," Mr. Kappel said.

L. W. Morrison

J. P. Molnar

R. R. Hough

R. R. Hough Elected Vice President of the Laboratories

As a result of the increasing volume of work for the Armed Forces done at the Laboratories, a second Vice Presidential area has been established to handle programs for the military.

R. R. Hough, Director of Military Electronics Development, has been elected a Vice President of the Laboratories to head the new area. Vice President W. C. Tinus will continue in charge of the existing Vice Presidential area devoted to military programs, which he now heads.

L. W. Morrison and J. P. Molnar have been appointed Director of Guided Missile Development and Director of Military Development, respectively. They head two new general departments in Mr. Hough's area. J. M. West, Director of Military Systems Engineering, and his present organization have also been included in Mr. Hough's area.

H. G. Och and C. A. Warren have been appointed Directors of Military Systems Development. They report to Mr. Morrison. P. S. Darnell, Director of Military Apparatus Development, and his present organization, and E. P. Felch, appointed Director of Military Systems Development, replacing Mr. Molnar, report to Mr. Molnar. W. H. C. Higgins, Director of Military Electronics Development, and E. H. Bedell, Director of Military Design Engineering, with their present organizations report to Mr. Tinus. An additional group headed by Mr. Tinus at the general department head level remains in his area.

Mr. Hough was graduated from Princeton University in 1939 with a B.S.E. degree, returned to the Princeton Engineering School as an instructor and graduate student and received an E.E. degree in 1940. He immediately joined Bell Laboratories and in 1941 became one of a group pioneering in the development of radar. He participated in the design and installation of the first U. S. naval gunfire control radar and made important contributions to the development of an army aircraft gunlaying radar. He received a War Department Certificate of Appreciation in 1946. In January, 1951, he was appointed Military Development Engineer, and in 1953, Director of Military Systems Development. He was named Director of Military Electronics Development in June, 1955. In 1947, he was the recipient of the Eta Kappa Nu Award as the "outstanding young electrical engineer."

Mr. Molnar was graduated from Oberlin College in 1937 with the A.B. degree, and received the Ph.D. degree from Massachusetts Institute of Technology in 1940. Prior to joining the Laboratories in 1945, he was employed with the National Defense Research Committee and with the Gulf Research and Development Company. Since joining the Laboratories, Mr. Molnar has been concerned with research in physical electronics and later with the development of microwave tubes. In 1955, he was appointed Director of Electron Tube Development and later in the year, he was named Director of Military Systems Development.

Mr. Morrison received his Bachelor's degree in Electrical Engineering at the University of Wisconsin in 1930 and after a year's graduate work joined the Laboratories, where he was engaged in the development of telephone and television terminal equipment for the coaxial cable system. During the war, he was a project engineer on the development of various radar systems. In 1945, he was placed in charge of a group engaged in the development of television transmission over wire and coaxial cable facilities. He was named Military Development Engineer in 1951, Director of Military Equipment Development in 1953 and Director of Military Systems Development (Air Force) in 1954. He assumed his present post in June, 1955.

Walter H. Brattain Describes Ceremonies at Presentation of Nobel Prize

This account of the 1956 Nobel Prize Ceremonies in Stockholm was taken directly from notes prepared on the scene by Walter H. Brattain, co-winner of the Nobel Prize in Physics with John Bardeen and William Shockley.

After several days crowded with a variety of activities, on Monday, Dec. 10, the 1956 Nobel laureates were driven from their hotel to the Stockholm Concert Hall for the prize award "solemnities" (so-called because the occasion marks the anniversary of Alfred Nobel's death). At the end of the drive through heavy traffic in the gathering dusk of Stockholm, the laureates assembled in an anteroom of the Hall. Walter Brattain describes the ceremonies that followed in his own words.

"We waited until the audience was all seated and the Royal family had come in (to the main chamber), to the fanfare of trumpets. Then we marched in, to more fanfares, led by two student marshals in sashes with the Swedish colors. We went in, in a double line, each with a sponsor on his left. We sat down in a "V" of chairs formed around the podium on the stage – the laureates on the right and sponsors on the left. The arms of the V faced each other, and the audience at an angle. The audience and Royal family stood as we came in. As each of us arrived at his seat he bowed to the Royal family and then sat down. The Royal family was seated in a row of chairs just in front of the audience. All except children were in full dress.

"The program began with a speech by His Excellency the Lord High Chancellor Ekeberg in honor of Nobel on the 60th anniversary of his death (Lars Birger Ekeberg is president of the Nobel Foundation). After this, the orchestra played a Serenade by Dag Wirén. This was followed by a speech sponsoring the physics prize winners made by Professor Rudberg. All speeches were in Swedish, but at the end Professor Rudberg turned to us and extended his remarks in English. Appropriately, he mentioned the fact that we had, in a sense, stood on the shoulders of all the other workers in our field to mount a summit that they had not reached. As he mentioned each of our names we stood and walked forward on the stage to face the audience. We then bowed and proceeded one after the other down the steps to our right. We then went forward again one at a time to accept our prize from the King. You bow to the king, listen to him as he presents the medal and scroll, and accept these in your left hand. This leaves the right hand free to shake hands with the King while saying "Thank you, Your Majesty." You then step past the King, sideways so as to not turn your back, bow to the Queen and continue sideways, until reaching the stairs to the left. The correct procedure is to then make an inside turn, mount these stairs and at the top, face the audience, bow again and return to your seat. Shockley went first, followed by Bardeen and then me.

"One does not really hear what is being said to him by the King. While he is receiving the prize a fan-fare is being blown for the previous laureate,

Medal for the Nobel Prize in Physics

Diploma received by W. H. Brattain at Nobel ceremonies.

and anyway one is in such a state of mind that, even if the King shouted, one probably would not hear or remember.

"After all the prizes were awarded in the order mentioned in Nobel's will we stood up as the Swedish National Anthem was played and the King and Royal family walked out.

"I am sorry that I do not have a picture of the Concert Hall as it appeared from where I sat. It was a grand sight, with tier upon tier of seats in a horseshoe all filled with people. At each door student marshalls stood at attention. These marshalls were relieved every fifteen minutes by other students. The front of the stage was banked with yellow chrysanthemums. Back of us on stage sat the Nobel laureates of other years who were present and members of Academies and Institutes responsible for choosing the prize winners.

"Following the ceremonies we congratulated each other, stood in a group for pictures and proceeded back to the anteroom. We turned in our medal and scrolls so they could be exhibited at a dinner that night.

"I have described the climax of a truly great experience the like of wich I can hardly appreciate fully, much less describe adequately. For fifty days, from the time of the announcement until the return from Sweden, one is exalted beyond all reason; first by your friends and then by the gracious and courteous Swedish people. These people arrange everything so well – they even assign to each Nobel laureate a young career diplomat from their foreign office as a personal "attendant." Everybody vies for a chance to honor you; the Royal family, the Nobel Foundation, the Royal Academy of Sciences, the Nobel Institute of Physics and many others. They all, as representatives of the Swedish people, have helped to administer the Nobel bequest in such an outstanding manner that these awards are recognized by the whole world as unique in their scope."

Talks by Members of the Laboratories

During January, a number of Laboratories people gave talks before professional and educational groups. Following is a list of speakers, titles, and places of presentation.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS WINTER GENERAL MEETING, NEW YORK CITY.

Barnes, Mrs. M. W., see Basseches, H.

Basseches, H., and Barnes, Mrs. M. W. *The Gassing of Liquid Dielectrics Under Electrical Stress. The Influence of Voltage and Pressure.*

Bozorth, R. M., *Scientific Visit to Russia.*

Clemency, W. F., see Romanow, F. F.

Emling, J. W., *General Aspects of Handfree Telephony*

Gleichmann, T. F., see last paragraph.

Kelly, M. J., see last paragraph.

Lebert, A. W., see last paragraph.

Lewis, W. H., see last paragraph.

Mertz, P., *Information Theory Impact on Modern Communications.*

Mottram, E. T., see last paragraph.

O'Brien, J. A., *Shift Register Decimal Counter.*

Romanow, F. F., Clemency, W. F., and Rose, A. F., *The Bell System Speakerphone.*

Rose, A. F., see Romanow, F. F.

Ross, I. M., *Properties and Applications of Transistor Switches.*

Slepian, D., *Binary Codes for Combating Noise.*

The following members of the Laboratories participated in the Joint Conference of American Institute of Electrical Engineers, Engineers Institute of Canada and Institution of Electrical Engineers over the transatlantic telephone cable, Hotel Statler, New York City: M. J. Kelly, E. T. Mottram, W. H. Lewis, A. W. Lebert, and T. F. Gleichmann.

AMERICAN PHYSICAL SOCIETY, NEW YORK CITY.

Clogston, A. M., see Geshwind, S.

Dillon, J. F., Jr., *Ferrimagnetic Resonance in Yttrium Iron Garnet at Liquid Helium Temperatures.*

Eisinger, J., and Feher, G., *The Hyperfine Structure Anomaly (HFSA) of* Sb^{21} *and* Sb^{123} *Measured by the Electron Spin Double Resonance Method (ESDR).*

Feher, G., see Eisinger, J.

Feher, G., *Electronic Structure of F- Centers by the Electron Spin Double Resonance Technique.*

Geballe, T. H., *Thermoelectricity and Conduction in InSb.*

Geshwind, S., and Clogston, A. M., *Ferromagnetic Resonance on Truncated Spheres of Single Crystals of Manganese Ferrite.*

Hrostowski, H. J., and Kaiser, R. H. *Acceptor States in Silicon.*

Hutson, A. R., *Seebeck Effect in ZnO.*

Kaiser, R. H., see Hrostowski, H. J.

American Chemical Society In Miniature, Seton Hall University, South Orange, New Jersey.

Hansen, R. H., see Hawkins, W. L.

Hawkins, W. L., Hansen, R. H., Loeffler, B. B., Lanza, V. L., and Matreyek, W., *Thermal Antioxidants for Polyethylene Containing Carbon Black.*

Lanza, V. L., see Hawkins, W. L.

Loeffler, B. S., see Hawkins, W. L.

Lundberg, J. L., see Nelson, L. S.

Matreyek, W., see Hawkins, W. L.

Nelson, L. S., and Lundberg, J. L., *Flash Irradiation of Polymers in the Visible and Near Ultraviolet Regions.*

Stephens, S. J., *Adsorption and Reaction of Evaporated Films – Ethylene and Oxygen on Palladium.*

Other Talks

Anderson, O. L., *Frontier of Research on Strength of Glass Fibers,* General Electric Research Laboratory, General Electric Company, Schenectady, N. Y.

Baker, W. O., *Chemistry – Profession or Business?,* American Institute of Chemists, Montclair State Teachers College, Montclair, N. J.

Bangert, J. T., *Network Synthesis,* Syracuse Section, I.R.E., Syracuse, N. Y.

Barrett-Smith, T. I., Jr., *Electronic Switching,* Summit Chapter, Toastmaster International, Summit, N. J.

Beck, A. C., *Waveguides for Long Distance Communication,* Syracuse Section, I.R.E., PGMT&T, Syracuse, N. Y.

Becker, J. A., *Rewards of a Science Career and Preparation for Such a Career,* Physics Club, Summit High School, Summit, N. J.

Biondi, F. J., *Review of Transistor Technology,* Electrical Engineering Graduate Seminar, Johns Hopkins University, Baltimore, Md.

Blefary, V. F., *Solar Energy,* Ramapo Reformed Church Adult Fellowship Group, Mohawk, N. J.

Boyle, W. S., *Far Infra-Red Spectroscopy of Conduction Electrons,* Physics Colloquium, Dartmouth College, Hanover, N. H.

Brattain, W. H., *Semiconductor Surfaces with an Electrolytic Analogy to Semiconductor Phenomena,* Physics Colloquium, Princeton University, Princeton, N. J.

Chapin, D. M., *Direct Conversion of Solar Energy to Electrical Energy,* A.I.E.E., Schenectady, N. Y.

Chapin, D. M., *Direct Conversion of Solar Energy to Electrical Energy,* Akron Section, American Chemical Society, Akron, Ohio.

Ciccolella, D. F., *The Bell Solar Battery,* Waterbury Section, American Society of Mechanical Engineers, Waterbury.

Fox, A. G., *New Horizons for Microwaves,* Piedmont Section, I.R.E., Burlington, N. C.

Frisch, H. L., *The Time Lag in Nucleation,* Dept. of Chemistry, University of California, Berkeley, Calif.

Frisch, H. L., *Poincare Recurrences and The Approach to Equilibrium,* Department of Physics, Western Reserve Unit, Cleveland, Ohio.

Frisch, H. L., *The Approach to Equilibrium,* University of Southern California, Los Angeles, Calif.

Harvey, F. K., *Speech, Hearing, and Music,* Colloquium at Sandia Corp., Sandia Base, Albuquerque, N. Mex.; Albuquerque Los Alamos Section, I.R.E., University of New Mexico, Albuquerque, N. Mex.; Dallas Section, I.R.E., Southern Methodist University, Dallas, Tex.

Lax, M., *Radiationless Transistors in Solids,* Watson Scientific Computing Laboratory, IBM, New York City.

Leslie, E. R., *Evaluation of the Test Methods for Gouge Resistance and Surface Abrasion Resistance Developed by Porcelain Enamel Institute,* Graduate Seminar, Rutgers University, New Brunswick, N. J.

Lewis, W. D., *Digital Computing Techniques in Telephone Switching,* Lexington Subsection, A.I.E.E., University of Kentucky, Lexington, Ky.; Louisville Section, A.I.E.E., University of Louisville, Louisville, Ky.

Maxwell, B., see Westover, R. F.

McCall, D. W., and Slichter, W. P., *Molecular Motion in Polyethylene,* Polymer Symposium, Polytechnic Institute of Brooklyn, Brooklyn, N. Y.

McDavitt, M. B., *Transatlantic Submarine Telephone Cable,* Morristown Chamber of Commerce, Morristown, N. J.

McNally, J. O., *Long Life Vacuum Tubes for a Long Distance Communication Project,* Nashville Section, I.R.E., Nashville, Tenn.

McNally, J. O., and Veazie, E. A., *An Electron Tube for a Repeatered Submarine Telephone Cable System,* American Society for Testing Materials, Committee Fl, Washington, D. C.

Monro, S., *Quality Control in Research and Development of Basic Units – Producer's View,* Washington Chapter, American Society Quality Control, Washington, D. C.

Noble, C. R., *Transatlantic Cable with film "Voice Under the Sea,"* Rotarian Club, Towson, Md.

Paterson, E. G. D., *Some Observations on Quality Assurance and Reliability,* Third National Symposium, Reliability and Contral Quality, Washington, D. C.

Pfann, W. G., *Recent Developments in Zone Melting,* Washington Chapter, American Society for Metals, Washington, D. C.

Scovil, H. E. D., *Some Effects of Spin-Spin Interactions on Spin Lattice Relaxation Times,* Conference on Spin Lattice Relaxation Time, Columbia University, N. Y.

Slichter, W. P., see McCall, D. W.

Slichter, W. P., *Nuclear Magnetic Resonance in Some Fluorine Derivatives of Polyethylene,* Polymer Research Institute, Polytechnic Institute of Brooklyn, Brooklyn.

Smith, K. D., *A Status Report on Transistors,* Columbus Section, I.R.E., Columbus, Ohio.

Suhl, H., *Some New Results in Ferromagnetic Resonance,* Physics Colloquium, Harvard University, Cambridge.

Veazie, E. A., see McNally, J. O.

Westover, R. F., and Maxwell, B., *Flow Behavior and Turbulence in Polyethylene,* Thirteenth Annual Technical Conference of Society of Plastics Engineers, St. Louis.

Wright, S. B., *The Dew Line – Its Objectives and Some Problems in Construction and Communication in the Arctic,* Collins Radio Technical Association, Cedar Rapids.

Papers Published by Members of the Laboratories

Following is a list of the authors, titles, and places of publication of recent papers published by members of the Laboratories:

THE ENCYCLOPEDIA OF CHEMISTRY – BOOK PUBLISHED BY REINHOLD PRESS, NEW YORK, JANUARY, 1957.

Bridgers, H. E., *Germanium and Its Compounds*, p. 445.

Bridgers, H. E., *Semiconductors*, pp. 852-853.

Edelson, D., *Polar Molecules*, pp. 767-769.

Flaschen, S. S., *Calcination*, pp. 161-162.

Garn, P. D., *Electrolysis*, pp. 341-342.

Hawkins, W. L., *Autoxidation*, p. 116.

Kunzler, J. E., *Calorimetry*, pp. 163-165.

Law, J. T., *Vacuum Techniques*, pp. 964-965.

Lundberg, C. C., *Antiozonants*, pp. 97-98.

Lundberg, J. L., *Solutions*, pp. 873-874.

Nelson, L. S., *Olefin Compounds*, pp. 661-663.

Potter, J. F., *Porosity*, pp. 775-776.

Reiss, H., *Thermodynamics*, pp. 930-933.

Schlabach, T. D., *Photometric Analysis*, pp. 735-736.

Slichter, W. P., *Paramagnetism*, p. 700.

Van Uitert, L. G., *Equilibrium*, pp. 363-364.

Wernick, J. H., *Carbonates*, pp. 173-174.

OTHER PAPERS

Anderson, J. R., *A New Type of Ferroelectric Shift Register*, Trans. I.R.E., PGEC, EC-5, pp. 184-191, Dec. 1956.

Anderson, P. W., see Clogston, A. M.

Augustyniak, W. M., see Wertheim, G. K.

Bala, V. B., see Matthias, B. T.

Bashkow, T. R., and Desoer, C. A. *A Network Proof of a Theorem on Hurwitz Polynomials and Its Generalization*, Quarterly Appl. Math., **14**, pp. 423-426, Jan. 1957.

Breidt, P., Jr., Greiner, E. S., and Ellis, W. C., *Dislocations in Plastically Indented Germanium*, Acta Met., **5**, Letter to the Editor, p. 60, Jan., 1957.

Burke, P. J., *The Output of a Queueing System*, Operations Research, **4**, pp. 699-704, Dec., 1956.

Clogston, A. M., Suhl, H., Walker, L. R., and Anderson, P. W., *Ferromagnetic Resonance Line Width in Insulating Materials*, J. Phys. Chem. Solids, **1**, pp. 129-136, Nov., 1956.

Corenzwit, E., see Matthias, B. T.

D'Amico, C., and Hagstrum, H. D., *An Improvement in the Use of the Porcelain Rod Gas Leak*, Rev. Sci. Instr., **28**, p. 60, Jan., 1957.

Desoer, C. A., see Bashkow, T. R.

Ditzenberger, J. A., see Fuller, C. S.

Ellis, W C., see Breidt, P., Jr.

Flaschen, S. S., see Garn, P. D.

Fry, T. C., *Automatic Computer in Industry*, Am. Stat. Assoc. J., **51**, pp. 565-575, Dec., 1956.

Fuller, C. S., and Ditzenberger, J. A., *Effect of Structural Defects in Germanium on the Diffusion and Acceptor Behavior of Copper*, J. Appl. Phys., **28**, pp. 40-48, Jan., 1957.

Galt, J. K., and Kittel, C., *Ferromagnetic Domain Theory, Solid-State Physics*, Advances in Research and Applications (book), **3**, pp. 437-564, 1956, Academic Press, Inc., New York.

Garn, P. D., and Flaschen, S. S., *Analytical Applications of Differential Thermal Analysis Apparatus*, Anal. Chem., **29**, pp. 271-275, Feb., 1957.

Garn, P. D., and Flaschen, S. S., *Detection of Polymorphic Phase Transformations by Continuous Measurement of Electrical Resistance*, Anal. Chem., **29**, pp. 268-271, Feb., 1957.

Greiner, E. S., see Breidt, P., Jr.

Hagstrum, H. D., see D'Amico, C.

Karp, A., *Japanese Technical Captions*, Proc. I.R.E., Letter to the Editor, **45**, p. 93, Jan., 1957.

Kulke, B., and Miller, S. L., *Accurate Measurement of Emitter and Collector Series Resistances in Transistors*, Proc. I.R.E., Letter to the Editor, **45**, p. 90, Jan. 1957.

Matthias, B. T., Wood, E. A., Corenzwit, E., and Bala, V. B., *Superconductivity and Electron Concentration*, J. Phys. Chem. Solids, **1**, pp. 188-190, Nov., 1956.

McMillan, B., *Two Inequalities Implied by Unique Decipherability*, Trans. I.R.E., PGIT, IT-2, pp. 115-116, Dec., 1956.

Miller, R. C., see Smits, F. M.

Miller, S. L., see Kulke, B.

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Second Bell System Science Show to be Telecast on March 20

"Hemo the Magnificent," the second in the Bell System Science Series, will be telecast in color over the CBS network on Wednesday, March 20, at 9:00 p.m., EST. As in "Our Mr. Sun," the story line of "Hemo the Magnificent" is carried on by Dr. Research and Fiction Writer with their magic screen and their science screen. Hemo, the title role, is a cartoon personification of the blood.

Frank Baxter and Richard Carlson talk with "Hemo" on the Magic Screen.

Dr. Frank Baxter again plays the role of Dr. Research, and Richard Carlson is the Fiction Writer. Frank Capra, who was praised for his creative imagination in using live action, animation and documentary footage to present authentic scientific content in "Our Mr. Sun," is again the director-producer.

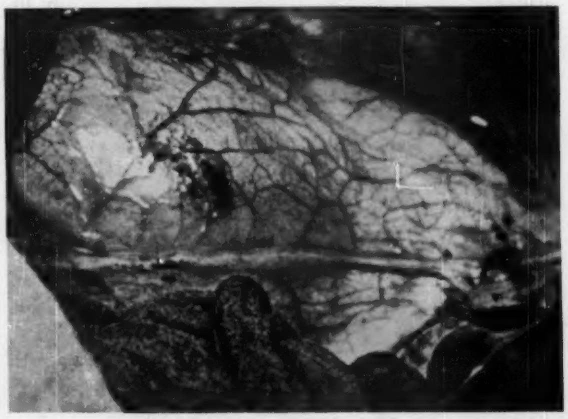
The Bell System Science Series is designed to promote through the medium of television a greater interest and understanding of the role of science in modern life and to present to younger viewers the challenges and rewards of a scientific career. The inaugural offering in the Science Series, "Our Mr. Sun," received widespread acceptance for its contribution to the field of education by presenting accurate and interesting scientific information with a high degree of entertainment value. To further the aims of the Bell System series, 16mm copies of the films in the series will be distributed to the film-lending libraries of all the associated companies following the nationwide telecast. These will be made available to local school systems on request.

A Scientific Advisory Board, whose members were chosen not only for their standing in the fields of science, but also for their interest in the popular presentation of scientific information, selects the material treated in the Bell System Science Series.

"Hemo the Magnificent" has an additional group of advisors who are experts in physiology. They include: Dr. Maurice B. Visscher, University of Minnesota, principal advisor; Dr. Chauncey D. Leake, Ohio State University, associate advisor; Dr. Gordon K. Moe, State University of New York, associate advisor; and Dr. Allan Hemingway, University of California at Los Angeles, consultant.

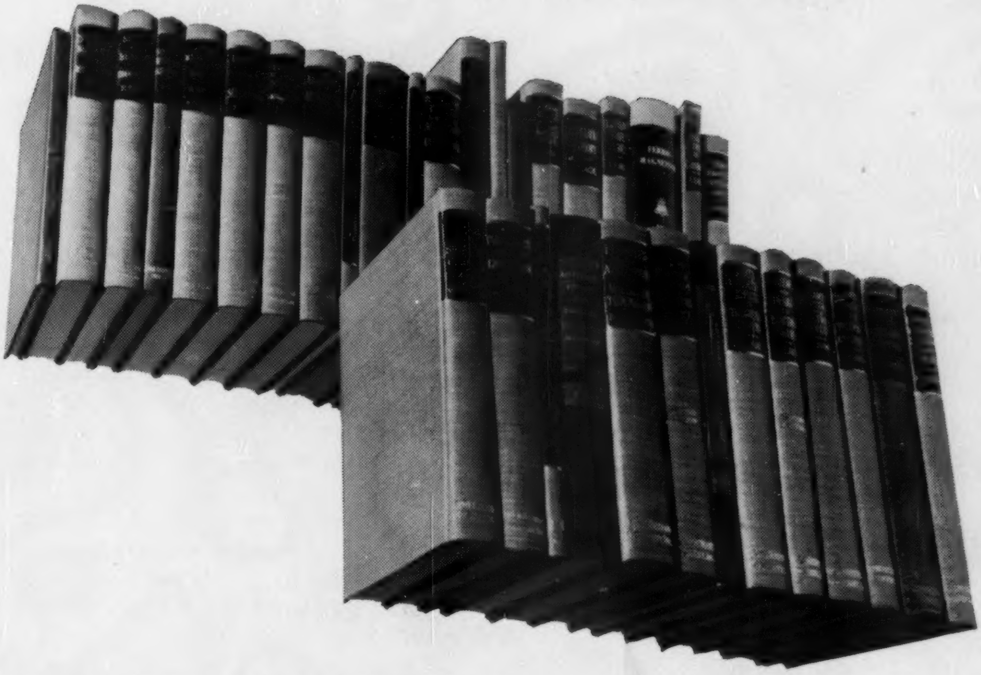
"Hemo the Magnificent" begins with a description of ancient man's concept of blood as something magic. It points out that modern knowledge about the blood began in 1628 with the work of the English scientist William Harvey, who discovered that it circulates through the body in arteries and veins. This is illustrated in an animated sequence that shows the pumping operation of the heart, the function of the lungs in providing oxygen to the blood, the function of other organs in providing food products to be distributed by the blood, and the work of the kidneys in purifying the blood.

The film describes the heart itself, which contains the hardest-working muscle in the body, and the arteries, veins and capillaries that make up the circulatory system. It also presents one theory to account for the composition of the blood by tracing its possible evolution from sea water.



A scene from "Hemo the Magnificent" shows a heart in action.

The books . . .



How the scientific world shares in fruits of the telephone art

In their work to improve telephony the scientists and engineers of Bell Telephone Laboratories make important findings in many sciences. They thoroughly report these findings in professional journals and magazines. But sometimes, as knowledge accumulates in a vital field, a "treatment in depth" is prepared in book form.

Bell Laboratories authors have written 36 books to date and others are in preparation. Many have become classics in the Laboratories' primary field of communications. Many have become standard works of wide application because they provide a fundamental guide for technologies in other fields. For example, the design of automatic switching systems is of primary importance in computers; statistical quality control provides the indispensable basis for economical manufacture. Through their books these scientists and engineers and the Laboratories attempt to repay benefits they receive from the published works of others.

The portraits at the right and below show some of the Bell Telephone Laboratories authors of technical books.

John R. Pierce, Ph.D., California Inst. of Tech., author of "Traveling-Wave Tubes."

Harold S. Black, B.S. in E.E., Worcester Polytechnic Inst., author of "Modulation Theory."

W. Thornton Read, M.S., Brown University, author of "Dislocations in Crystals."

. . . the authors

Most of the books written by Laboratories authors are published by D. Van Nostrand Company. Others publishers include John Wiley & Sons and McGraw-Hill. Subjects include speech and hearing, mathematics, transmission and switching circuits, networks and wave filters, quality control, transducers, servomechanisms, quartz crystals, capacitors, visible speech, earth conduction, radar, electron beams, microwaves, waveguides, antennas, traveling-wave tubes, semiconductors, ferromagnetism.

Richard M. Bozorth, Ph.D., California Inst. of Tech., author of "Ferromagnetism."

Walter A. Shewhart, Ph.D., University of California, author of "Economic Control of Quality of Manufactured Product."

Hendrik W. Bode, Ph.D., Columbia University, author of "Network Analysis and Feedback Amplifier Design."

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